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THE ISLAND OF MINDORO.

BY J. B. STEERE.

THE island of Mindoro is the Philippine land of myth. Lying near the route of the native trading boats in their voyages from north to south, and of the war and piratical expeditions for which the Philippines have been famous, it has been frequently coasted along and visited by natives of the other islands, but appears never to have been permanently occupied by them and the Spanish until very recently. It is still inhabited almost entirely by its own wild, independent tribes, many of which have probably never yet heard of the Spaniard, and know nothing of the great sea but what they have seen from their mountain homes. It is difficult to account for this fertile island lying thus uncultivated and peopled only by a few savages, while surrounded near at hand by overpeopled and overcultivated islands. Perhaps the reputation the island bears for malaria and savage inhabitants may have had its effect; while the fact that it has become the safe refuge of criminals and outlaws from the other islands about it has added to its bad reputation. We had everywhere heard stories of Mindoro and its savage beast,—the *tamarou.* One ship captain we had traveled with had lately lost a brother at the southern end of the island, where he had gone with his vessel for a load of timber. He and his company were attacked while at dinner, and all killed but one. A tribe was said to exist in the interior, of people as white as the Spaniards, but so fierce that they killed all strangers who approached their villages. The *tamarou* takes the place, in the stories of the Philippine-islanders,

of the elephant in those of other eastern peoples. Some had described it to us as a great beast with one sharp horn in the middle of its forehead; and all stories agree as to its great speed and fierceness in attacking men and other animals at sight.

We knew that the island had been but little studied in a scientific way; but our curiosity and our anxiety to visit it was much increased by the Spanish governor of Mindoro, who is also governor of Marinduque, and who visited the latter island during our stay. I asked him what scientific study of the island had been made, and he answered: "*Ni bien ni mal*" (neither well nor ill,—not at all). He said a Spanish scientific commission had landed there once since he had been governor, but had gone away without visiting the interior, for fear of the malaria. It was then with a great deal of interest that we looked across the strait to the west to the lofty mountains of the island, which were continually in our sight, and planned our trip to this unknown land. The visit of the governor was a fortunate one for us, for we found that one of the passenger steamers from the south would call on its way to Manila and take him directly across the strait; otherwise we should have been compelled to hire a native boat, or to have gone to Manila and returned from there to Mindoro. The time of the steamer was not closely fixed, so that for two or three days we were half packed up, and dared not go far away in hunting. But finally, one afternoon, the lookout gave notice that the steamer was in sight; and half an hour afterwards the goods of the governor were being hurried down to the beach on buffalo carts, and our own soon followed in the same manner, and were piled on the sand just above the tide, where they were taken by the ship's boats and carried out to the steamer, which lay at anchor half a mile away. Just at night we got on board ourselves, while the anchor was being hauled up, and after a quiet voyage across were landed, near midnight, at the port and town of Calapan, again by the ship's boats, and at a long bridge or wharf of wood supported by piles and running two or three hundred feet out into the bay. A part of this was roofed over, and some of us swung our hammocks here, while the others camped with their guns among the baggage, which was piled on the beach under

the open sky, for we had again, for the third time, outrun the rainy season in its slow advance from the southeast. The next morning showed us a bay partly sheltered by several small islands, and the little town of Calapan scattered along a low, narrow point of land between the bay and a tidal river behind. At the landing from the wharf was a little plaza, now surrounded by posts (for they lately had a bull fight there), and behind this the stone fort and its high wall, where was quartered a company of Indian troops. Behind this, a short distance, was a low bridge across the river. We were soon able to find a house for rent, and moved in and got our breakfast at home. We were fortunate in securing as cook an old Indian, Juan, who was said to have cooked for a Spaniard at some time in his life. A stroll down the street showed me a blacksmith shop, a few doors away, under an open roof of palm-thatch and bamboo, and between that and us a continuous line of native houses, palm-thatched and as dry as tinder. I had with me nearly the entire results of the year's work in the Philippines, including several dozens of new and undescribed species. The thought of our personal danger in being burned up in the tinder-box in which we lived never occurred to me; but the danger of the collections became such a burden that I could hardly sleep, and the great trunks of skins and other collections were so arranged that they could be at a moment's warning dragged down to the yard below.

Calapan is the capital of the island, and possesses perhaps a dozen Spanish officials, a few Chinese, and five or six hundred Christian Indians, the latter drawn chiefly from Luzon and and Marinduque opposite.

We were so anxious to see what the island produced that several of the party went out the same day to the patches of virgin forest on the low hills near the town. The settlement is quite recent, and stumps and native timber are still abundant. Mateo was the first to return, with a lot of birds which were at first sight disappointing. Most of the lot were birds we had already learned to expect as common inhabitants of all the Philippines; among these the common Philippine crow and oriole and barbet and black night-singing cuckoo, *Eudynamis*. Several genera which

we had learned to expect in local species in each well-marked division of the islands were wanting entirely, and our trips inland afterwards failed to discover them. Among these genera conspicuous for their absence were two of the three commonly distributed genera of hornbills, three of the four genera of woodpeckers, and several genera of kingfishers and cuckoos. Among the new birds brought in was a little parrot, Loriculus, closely resembling the Luzon species, but sharply distinct from it; and a new species of the genus of small black hornbills (Penelopides). We had found the five species of this genus already collected with the male always white-headed and the female with the head black like the body; but our Mindoro species was white-headed in both male and female, the only distinction in color between the sexes being that the male had the bare skin about the face flesh white, while the female had the same parts livid blue. A little way back among the hills another crow was found, much smaller than the common crow and with a shorter tail, and flight resembling that of the parrots. This little crow had a curious flat voice, reminding one of the croaking of frogs and also of the notes of the katydid. On dissection it proved to be distinct in food from the common species, being limited to fruit. We were soon visited by several collectors of land and tree shells,—the same ones who by sending quantities of their collections to Manila have made the beautiful Mindoro tree snails well known in Europe. The Mindoro species are apparently more peculiar than those of Paraguay, there being several sections of genera limited to this island.

The *tamarou* were said not to be found within less than two days' journey of Calapan; and as the rainy season was coming on, we hastened our preparations for our visit to the interior. That we might run the greater chance of getting the object of our search we decided to divide our party; and Bourns and Worcester set out by native boat a day's journey down the coast to the south, and then inland in their search for the lake Naujan, which was said to be a famous haunt for these animals. They found the lake to be of considerable size, but shallow and with great mud-flats, and much of it grown up with water plants and

filled with crocodiles. It is apparently an old arm of the sea, cut off, and now draining out by the rising of the land. It is surrounded by dense forests, only broken where there are a few cabins of outlaws and runaway Christian Indians, and a little village of Mangianes, a native heathen tribe. Signs of the *tamarou* were abundant, and they immediately set to work to kill some of them. The Indian plan was to build a stockade and enclose a tame buffalo, which the *tamarou* would come out to attack at night, when they might be shot at close quarters. They tried this several nights until they were nearly eaten up by mosquitoes, but no *tamarou* made their appearance, and they then undertook to hunt them by day. Their guides were too much afraid to lead them directly to the game, and when they were near would run away. But they got several shots and wounded one or two badly, but rain coming on the tracks were washed out and the game lost; and so, after two weeks of the hardest work and exposure, they returned to Calapan without the *tamarou*, but with two wild boars and a large collection of water birds from lake Naujan.

A few days after this portion of our party left for the south, Mr. Moseley took a native vessel across to the coast of Luzon, on his way to Manila and the United States; and Mateo and I, with old Juan, the cook, loaded a canoe with provisions and started up the coast to the north to the village at the mouth of the Catuiran river, where we expected to get a guide for the trip. The man who had been recommended to us was not yet ready, and we pushed on up the Catuiran. At its mouth it is wide and deep enough for native vessels of considerable size to enter. The country near the sea was low and covered with mangroves, and uninhabitable; but as we left this flowed country behind we came to new settlements of Christian people from Luzon and Marinduque, and pulling our canoe up the muddy bank below the house of one of these, who was recognized as an official by the government at Calapan, we claimed his hospitality and slung our hammocks under his narrow roof. These people were clearing the new and rich lands along the river, and raising mountain rice. The next day of waiting was spent in hunting along the river and through the deep forests around the clearings; but little new was found,

and the same paucity of species and lack of expected genera was noticeable. While we were here, baskets of fruit called *carago* were brought to us, of a kind entirely new to me, but apparently identical with a well-known Bornean fruit. They were hanging in clusters, and each fruit was of the size of a small orange, and strawberry red and covered with soft red spines. On opening the thin shell, which was much after the manner of the Chinese *lichi*, there was found a mass of light-colored, juicy pulp surrounding a large flattened seed. The fruit was excellent in quality, and appeared worthy of cultivation, though the circumstances may have had something to do with our appreciation of it. We at the same time heard of another fruit, not yet ripe, but so abundant and rich that the wild tribes got fat upon it. This was called *uli*, and from the description as well as the name must be the *durian* of the farther east. The next day Pedro, our guide, arrived,—a man of some consequence, and an owner of land and buffaloes. He came mounted upon a water buffalo, and with a boarspear as a weapon. The river now narrowed to fifty or sixty feet of water, and a broad bar of coarse sand or shingly gravel on one side, and on the other a low bank of ten or fifteen feet, reaching up to the level forest above. The stream appeared to approach gradually nearer the mountains, which were in plain sight on the right. Little clearings were scattered along the river for several miles, and our progress was so slow that as we neared the last of these the afternoon was half spent, and we stopped for the night. The next morning another Indian, Antonio, a famous crocodile hunter of the Catuiran, who had heard of our trip, joined himself to our party in the hope of meat and pay.

We now entered the unbroken wilderness, and Pedro led the way along the sand-bar on his buffalo, and I followed him on foot with my gun, while Mateo and Juan came with the canoe. The river was now made up of curious reaches of deep and sluggish water, of half a mile or so in length; and then there would be a shallow rapid for a few yards, over which the water roared as it dashed down, and where our men had to take hold of the canoe and by their force drag it up into the quiet water above. As the heat of the day came on the sand and gravel became as hot as

if heated in a furnace, and we would follow along under the shady side of the jungle whenever possible. Life was rare; a little kingfisher or a small gray heron would now and then take flight from among the driftwood, or we would see the great Philippine snake bird flying along the stream or perched on the driftwood, stretching its long neck at the approach of danger. On lighting in the water it would frequently sink and walk on the bottom, its head and neck standing out of the water above.

About noon we stopped at one of the rapids and waited for the canoe to come up. A snake bird I had shot had fallen in a lagoon formed in an old bed of the river, and one of the Indian boys mounted the buffalo and forced him to swim in after it. Crocodiles were plenty, so that he did not dare to go in alone. Tracks of tame buffaloes run wild, *cimarones*, were abundant and Pedro said that there were on the river somewhere some twelve or fifteen of his own run wild, with their young born in the jungle, making a herd of thirty or more. Here and there among these tracks he picked out smaller, rounder ones, which he said were the tracks of the *tamarou*. We passed soon after the mouth of a stream not now running, but with water in pools along its bed, which was called *rio muerto* (dead river), and was said to connect and give canoe passage across to the town of Calapan in the rainy season. About three in the afternoon two *tamarou* started out of the cane-brake within a few feet of us, and without breaking cover rushed into the forest behind. Pedro tied his buffalo to a bush, and taking my gun, started after the game. The canoe coming up soon after, the buffalo took fright and dashed away, and was in great danger of becoming a *cimarone*, but the whole party turned out and captured it, and Juan, the cook, mounting it, we moved on. Suddenly old Juan, who was ahead, came running back, shouting *tamarou* as loud as he could yell; and on hurrying around a bend we saw, a hundred yards away on the other bank of the river, what looked to me wonderfully like a buffalo calf,—and this did not take fright at Juan, who still kept shouting and calling down upon us all kinds of maledictions because we had no gun with us. Before the canoe came up with the other guns, two Indians (Christians)

appeared near the buffalo, and on crossing we found that they were gathering rattan, and had the calf's mother to pull the long stems out of the jungle to the beach. They had built a low shed on the beach near the edge of the woods; and as we had crowded about as far up the river as we could for the driftwood, we unloaded our canoe and set to work to add another shelter to the one existing, so as to cover our party. Some posts were set up in the ground and tied with rattan to each other and the old shed, and palm leaves were brought from the forest and tied on for a roof, and a shelter soon made, though the makers were so shiftless that I had to set them to do the work over three times before it would shed rain. Pedro, who had come in unsuccessful from his hunt after the *tamarou*, borrowed my gun again and set out up the river, and returned before night with a small wild boar, which was quickly fitted for the pot. He reported having seen two *tamarou* crossing the river. By dark it was raining, and hanging our hammocks with their mosquito nets from the posts of our shed, we went to sleep in our own new house. The Indians kept a great smoke all night to drive off the mosquitoes.

The next morning Mateo was out with the Winchester rifle soon after daylight, and just as we had got breakfast I heard the heavy boom of the gun, apparently half a mile away up the river and soon after there was another report, and then another and another was echoing back and forth in the thick, misty air from one side of the river to the other, until I had counted seven shots. Mateo was alone, and I had heard such stories of the ferocity of the *tamarou* that I was alarmed; but half an hour afterwards he appeared on the other bank below us, shouting: "I've got him, I've got him," and on my inquiring what, he answered: "An old bull *tamarou*." As he waded the river up to his middle, with the rifle above his head, I could see that his face was bleeding and his shirt torn off of one shoulder; but this was from the thorny jungle he had forced his way through, and from the sharp, cutting edges of the leaves of the wild canes. He had found a fresh track crossing the river, and followed it through the rich, soft bottom land almost as well as if in snow, until he saw the *tamarou* in the bed of a stream, drinking. After he had found a

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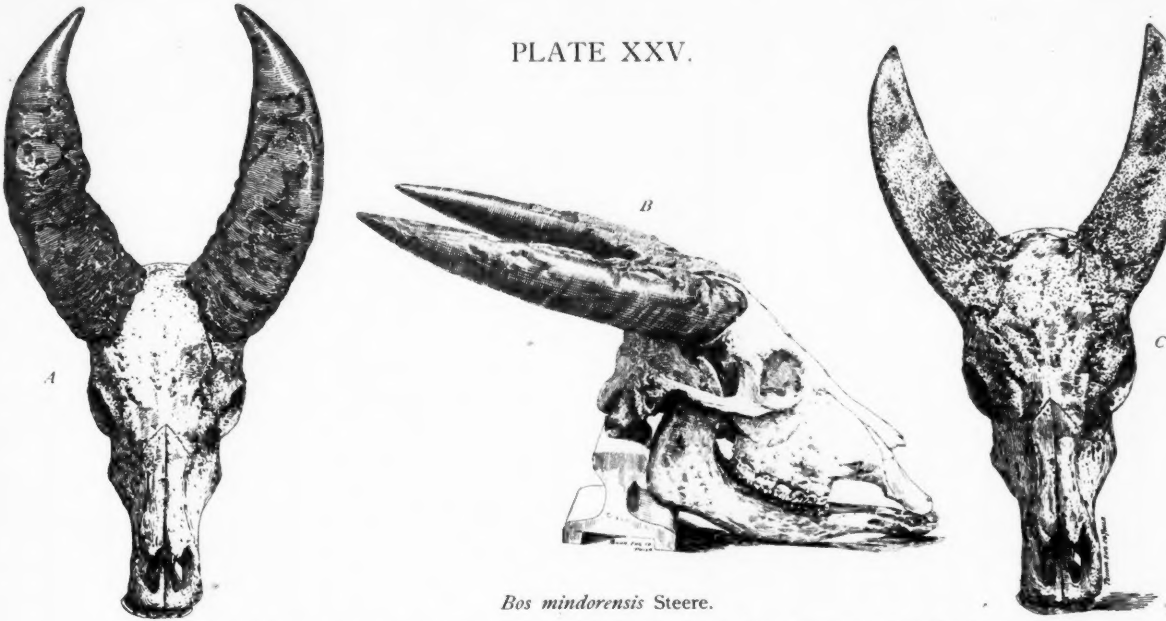
PLATE XXV.



Bos mindorensis Steere.

A, *B*, Skull, with sheath of horns, front and profile views; *C*, skull, front view, without horn-sheath.

tree that he could climb in case of trouble, he fired at its shoulder, and it fell, but got up immediately and came on toward the smoke, when Mateo fired again, and again knocked him down; and he repeated this until the animal was within thirty yards, when a bullet through his brain finished him, and, charging up the bank, he fell back into the little brook dead. A rude sledge of poles was built and the tame buffalo harnessed to this, and we set out up the river and along the beach until nearly opposite the game, when half an hour's hacking at cane-brake and bushes opened the way to our prize. We then rolled him upon our sledge, and, tying him fast by the horns, dragged him to our camp. To have actually been the first of civilized men to see and describe a mammal of this size and importance is a rare experience, and one that is fast growing rarer, as all parts of the earth are becoming known. There was no doubt of the relationship of the beast at first sight. It was a water buffalo, but so differing in size and color and shape of head and direction of horns from the ordinary species of the Philippines as to make it not only a distinct species, but also to probably place it in another genus. Our specimen was an old male, the size of a small Jersey cow, but lower and heavier, the body and limbs being almost perfectly round, and looking as if swollen with fat. It was lead-black in color, with lighter markings on head, legs, and under parts, with thin, short hair, a little switch-tail like a swine, and nearly straight, sharp, black horns, which ran upward and backward, spreading but little more than the width of the head, and being in line at the tips with the nose and eye. This narrowness and backward set of the horns gave the animal a peculiar look, but must be especially fitted for crowding its way through the wild vines and cane-brakes where it passes its life, the nose being thrust forward as with the water buffalo, and the horns thrown back on the neck. The skin was of immense thickness, and was entirely covered with gore marks of many battles. One rib had been broken and mended, and the old fellow was just recovering from a horn-thrust clean through one of his fore legs. Whether these were marks of battles among the *tamarou* themselves, or with the *cimarones* (buffaloes run wild), we could not determine; but the

Indians with us said that they were from battles with buffaloes, and that the *tamarou,* though only one-half or one-third the size of these huge animals, would attack them at sight, and that on account of their great speed and their sharper, straighter horns, they usually conquered. A measurement of our specimen showed it to be eight feet one inch in length from tip of nose to end of tail; tail, seventeen inches to tip; tuft of hair at tip of tail, two and one-half inches; height at shoulders, three feet four inches; height at hip, three feet six inches; fore leg to brisket, one foot seven inches; horns, seventeen and three-fourths inches in length; circumference at base, thirteen inches, somewhat triangular and heavily ridged; distance between bases of horns, one and one-half inches; width of horns, eleven inches apart. After measurements of another bull and a cow proved to agree almost exactly with this, the cow being eight feet in length to tip of tail. The horns were not so large at their bases, and were farther apart, and the neck was not so thick; otherwise the size and shape were practically identical. A calf perhaps three or four months old differed greatly from the adult in color, being chestnut, with a black line along the back and black markings upon the legs. On skinning our *tamarou,* the roundness was found to be due to the thickness of the skin and the immense development of the muscles. We found that two Winchester balls had passed through the heart, and that after this the animal had been able to get up and charge, showing as much vitality as a grizzly bear. I set our Indians at work cleaning the bones for a skeleton, while I undertook to preserve the skin, which, from its great thickness and the moist weather, was a difficult matter. Our fire was now surrounded by pieces of the meat, roasting; the kettle was full of meat, boiling; and old Juan set at it to make *tapa* (jerked beef) of the balance; while Antonio, who regularly borrowed one of our guns and went out to hunt *tamarou,* and as regularly returned without finding game, took the refuse and staked it down across the river, and said that now he would catch a crocodile. The night following we had rain again, which was favorable by washing out all old tracks, and the next morning Mateo was again successful, this time killing a cow, which we got to camp in the

same way as before. Under the hot sun and the frequent rains our camp began to take on a decidedly strong odor, and meat was plenty. Word somehow got down the river to the settlement, and several Indians came up with their buffaloes, and loaded up with meat. Then for three days the weather was too rainy for Mateo to get *tamarou.* I was busy in hurrying my skins out into the air to dry, and then hurriedly folding them, and dragging them under shelter, when the showers came on; while old Juan was nearly distracted over his jerked beef, which was too high to be kept longer in our hut, and showed signs of running away of itself. A patch of open woodland lay back of our camp, and between showers I would get into this and kill a few of the great fruit pigeons to keep us in meat, while Mateo would get out whenever possible after *tamarou.* One evening he and Antonio had taken the buffalo and had gone up the river to tie the buffalo fast on the beach, in hope the *tamarou* would come out to attack it. I had already gone to bed in my hammock, which hung, covered by its mosquito net, under an open roof, and swung only a few inches above the sand. Before I got to sleep I heard a great splashing across the river, where Antonio had set a rattan lasso by the *tamarou* meat, and the Indians in camp took a torch, and crossing in the canoe, spent some time in tying the captured crocodile with rattans. I knew well how this was done. The hind and fore legs were tied over the back, and the jaws tied together, and then I was dimly conscious of their dragging the helpless fellow to the camp and tying him fast to one of the poles of our hut. In the night some time I was suddenly awakened by the sharp noise of the crocodile's jaws coming together, and by the pulling at the mosquito net and hammock curtain near one of my feet. Divining the cause, I roused the whole Indian camp by my shouts, when they pried the fellow's jaws loose, and again tying him fast, dragged him down near the river and tied him to a stake. They had tied him fast to the same post my hammock hung upon; he had worked his jaws loose, and seeing my foot move, had struck at it. The next morning a rattan rope was fastened about the crocodile's body just before the hind legs, and he was tied with some twenty

feet of slack to a sawyer in the river, just in front of our camp, and I had a good opportunity to watch him. He was terribly vicious, and would spring at anything that approached, making a hoarse, barking noise, which could be heard to some distance, and is a genuine voice. The next day we were visited by two savages of the Mangianes, as they were called by the Spanish and Christian Indians. They were much the same in color and general appearance as the Christianized races, but were smaller and dirtier. The man had a handkerchief tied about him for an apron; but the woman, who was entirely naked to her waist, wore a curious petticoat, made up of a long, narrow ribbon of braided rattan, which was wound round and round her hips, until it took the form of a petticoat, and was held in place by a band of bark cloth, passing between the legs and fastened to the waist. They were both barefooted, and the woman was armed with a wood knife and the man with rude bow and arrows. We had just killed the crocodile, and were taking the flesh from the bones to make a skeleton, and they carefully gathered the meat from the sand and stored it away, as also such pieces of old Juan's jerked beef as he considered past hope. This they threw on the fire for a few moments, and then went about chewing it with evident enjoyment. They have the reputation of eating snakes among the other Indians. They begged tobacco and salt of us, and promised to bring us wild fruit and honey. Their village was too far away for us to visit. The day after they came again, bringing a basket of the red fruit before mentioned, and a great piece of honey-comb filled with honey. It was made by the big bees (*Apis striata*), which suspend their combs under horizontal limbs. On the seventh day of our stay Mateo killed a young bull *tamarou;* and after skinning it and cleaning the bones for another skeleton, as it continued to rain and the river was rapidly rising, we concluded to return. The next morning our canoe was loaded with the heavy skins and skeletons and the rest of our baggage, and when we got in with our guns the edge of the boat was within less than an inch of the water. A box containing most of Juan's *tapa* was taken out to lighten us a little, and we started in the rain, and, without stopping, we hur-

PLATE XXIV.

Bos mindorensis Steere.

ried down the river, and after many narrow escapes in the rapids, we reached the village at the mouth of the Catuiran just before dark. To make the canoe load lighter I set out, with three of the guns, on foot to Calapan, while the rest came up the coast, and about midnight we had everything under shelter in our house. Our skins and skeletons were great curiosities to the people of the town, and a great many of them visited us to see them. From the stories and remarks of the old settlers in Mindoro we learned much that was semi-authentic in regard to the *tamarou*. It is said to be very abundant on the opposite, uninhabited side of the island, and to there come down to the sea coast. Some said the cows had a habit, when the calves were young, of taking them in time of danger on the neck and holding them with the horns, and running with them in this way. Our host, who had been on the island many years, said that there was another *tamarou* of the mountains, much smaller. This story, from what we afterwards learned, probably refers to a mountain goat. As we found the *tamarou* and observed their habits, we found them chiefly living in cane-brakes, upon the young shoots of which they were feeding. At night they would gather in some numbers along the open beaches of the river. During the morning they would feed solitarily, or lie in the mud and water of the small streams, and later in the day would take refuge under certain trees, whose branches drooped to the ground, forming an almost impenetrable shelter. The tracks and wallows under these trees showed that much of the time the *tamarou* must occupy them.

The rainy season was now fairly begun, but Mateo offered to return to the Catuiran for more *tamarou* if I wished, while I should go on to Manila. Having fitted him and old Juan out for another expedition, I took the steamer, which came along near the end of June, and after a day's voyage was back in Manila, and settled in the same hotel we had occupied nearly a year before, on our arrival in the islands. On the way across I had felt premonitions of fever, and after I had got my collections all housed and in safety, and my baggage carried to my room, I was taken with a severe attack. As soon as I had recovered suf-

ficiently, I wrote a description of the *tamarou* and forwarded it to Professor Sclater, secretary of the Zoological Society of London. He published a part of the description in *Nature*, of August, 1888, and the full description in the "Proceedings of the Zoological Society of 1889." I then made a trip to the La Laguna de Bay, a great, shallow lake, some fifteen miles in length, and lying twenty miles east of Manila, toward the mountains, where there was some timber. I collected a few days, and, with the aid of native hunters, got a fair representation of Luzon birds, in spite of continual rain, which rendered the roads of the country impassible for horses. I then returned to Manila, and as soon as possible to Hong Kong, and from there home, by way of Japan and San Francisco.

THE COMPARATIVE MORPHOLOGY OF THE FUNGI

BY JAMES ELLIS HUMPHREY.

UNTIL a very recent date the whole history of the truly morphological study of the fungi might have been epitomized in the mention of two names,—Tulasne and DeBary. Beginning with the earlier publications of the brothers Tulasne, which culminated in their monumental "Selecta Fungorum Carpologia," and continued in the "Beiträge zur Morphologie der Pilze" and other works of DeBary and his students, the contributions to our knowledge of the structure of the fungi, their polymorphic fruit forms and their genetic relationships, have increased in number and importance. But the time has come when to the names mentioned must be added a third,—that of a pupil of DeBary, though for a long time not of his "school." It is now nearly twenty years since there appeared the first of a series of quarto memoirs, of which the tenth has just been issued, which give their author his conspicuous rank among myco-morphologists. The first six of the series may be regarded as preliminary studies, which contain the early views of their author, and record the dawnings of the broad morphological ideas which are developed in their completeness in the last four numbers. It is the primary purpose of this paper to present in outline to American readers the results and conclusions contained in these last four parts of the "Untersuchungen aus dem Gesammtgebiete der Mykologie" [1] of Prof. Brefeld, of the German Academy at Münster, in Westphalia. The parts named comprise 884 pages of text, with 37 lithographed plates, and their very bulk is perhaps a sufficient excuse for the present abstract; while the importance of their contents and the light which they throw on many heretofore doubtful forms and problems render at least a general knowledge of them of the greatest importance to any one who would keep him-

[1] Untersuchungen aus dem Gesammtgebiete der Mykologie. Von Dr. Oscar Brefeld, Ord. Professor der Botanik, etc. VII. and VIII. Hefte, Basidiomyceten. Leipzig, 1888-'89. IX. and X. Hefte, Die Hemiasci und die Ascomyceten. Münster, 1891.

self in line with botanical progress. And it may safely be predicted that their influence on the future study of the fungi will be of a most positive and fruitful character.

Assuming, with all writers on the subject, that the simplest and most primitive fungi, which retain undoubted sexual characters, the Zygomycetes and the Oömycetes, have been derived from the lower Algæ, we find them developing, in common with some of the latter, two types of reproductive organs: sexual organs, which usually produce resting-spores, and non-sexual organs. Of the latter, the sporangium of Mucor may be regarded as the most primitive type. In this we find a roughly globular sac of very variable size, raised upon a stalk, from whose contents (originally undifferentiated protoplasm) have been formed, at maturity, a large number of rounded spores, varying considerably in size and determined, as to their number, by their own size and that of the sporangium in which they were formed. The closely related genus Thamnidium[2] bears similar sporangia at the apices of erect hyphæ, and others of a second sort on lateral branches. These latter, known as sporangiola, are essentially only miniature sporangia, in which the number of spores has become reduced to four, or even two. In one species of Thamnidium the terminal sporangium is often aborted, leaving only the the sporangiolia; and the relative abundance of the two forms can be largely controlled by varying the conditions of the culture. From this condition of things it is an easy step to that in which the terminal sporangium is habitually suppressed, and the contents of the sporangiole have been reduced to a single spore. This condition is realized in Chætocladium, whose reproductive organs are no longer sporangiola which set free their spores by rupturing, but "closed sporangia" or conidia. A comparison of the two species of Chætocladium shows the last stage in the reduction. In *C. fresenianum* the conidium begins its germination by throwing off its outer coat, a process morphologically equivalent to the rupture of the sporangium-wall; but no such preliminary

[2] The forms referred to in the following pages will nearly all be found described, and many figured, in the English translation of DeBary's "Comparative Morphology of the Fungi," published by Macmillan & Co.

process occurs in *C. jonesii*, in which is thus reached the full character of the conidium.

Brefeld here adopts the familiar name previously applied to certain non-sexual spores, and extends to some extent, while in other directions limiting, its application, and gives it a definite morphological value. The conidium, then, may be defined as a reproductive organ, morphologically equivalent to the sporangium, and derived from it by reduction; or as a one-spored, closed sporangium. As the author well says, we have here a theoretically ideal series of stages, complete at every point. A similar set of steps leading from the sporangium to the conidium can be traced among the Oömycetous forms, although less complete and less convincing.

Not only does the development of the conidia-bearing threads or conidiophores vary widely in different species, but within the limits of species it may be greatly modified by external conditions. The study of the structure and development of a very large series of forms of Basidiomycetes has shown that in some instances the true basidia characteristic of these fungi are accompanied or preceded by conidiophores which under certain conditions assume a form practically indistinguishable from the basidia; and the facts brought out lead irresistibly to the conclusion that the *basidium*, with its sterigmata and spores, must be regarded as a definite and unvarying conidiophore. Two species which show this relation very clearly are *Pilacre petersii*, which, formerly of doubtful relationship, is here shown to represent a special type of primitive Basidiomycete, and that which the author calls *Heterobasidion annosum* (= *Polyporus annosus* Fr., *Trametes radiciperda* Hartig).

The basidia of the various Basidiomycetes are not of a single type, and cannot be referred to a common origin. Those of the simplest of the group are divided by cell-walls into several (usually four) parts, each of which gives rise to a sterigma and spore. And here we find two forms: basidia of elongated form, with transverse divisions, characteristic of Pilacre and Auricularia and of the Uredineæ; and basidia of rounded form, divided by walls parallel to their longer axes, occurring in the Tremellineæ,

which group is considerably reduced in size by this new limitation. The fungi comprised under the groups above mentioned constitute Brefeld's Protobasidiomycetes, in distinction to his Autobasidiomycetes, which form the main bulk of the order, and have undivided basidia. Nearly all of these latter have basidia of the familiar short form, with terminal sterigmata and spores; but in the genus Tulostoma the spores are borne laterally, and the basidia resemble those of Auricularia, without their divisions.

The important point to be noted here is that the basidium furnishes the essential character of the Basidiomycetes, as was long ago recognized by DeBary in the very appropriate name of the group, although on much less substantial morphological grounds; that the basidium is more fundamental than any form of fruit body, and that the very various fruit forms have grown up within the group after differentiation of the types of basidia from their ancestral conidial forms. This subsequent development of the fruit body has produced results so striking and has followed such similar lines in the two great groups of fungi—the Basidiomycetes and the Ascomycetes—that the tendency has been to emphasize the differences thus brought about, with the result that we have lost sight of the primitive character of the basidium and the ascus.

Among the Protobasidiomycetes we find in Pilacre a fruit form of angiocarpous structure, while the other forms are strictly gymnocarpous. Of the Autobasidiomycetes, the simplest gymnocarpous forms comprise the gelatinous Dacryomyceteæ, formerly included in the Tremellineæ; the Tomentelleæ, separated from the Thelephoreæ; and the Clavarieæ. The basidium of the first-named family is somewhat pitchfork-shaped, with two large sterigmata; but in the others we meet with the typical club-shaped basidium, with small, spine-like sterigmata. In the Tomentelleæ we have clearly the primitive Autobasidiomycetes, consisting of very loose wefts of hyphæ, upon which are borne, irregularly and indiscriminately, the basidia, which arise precisely as do the conidiophores of many other fungi. These pass into the definite fruit bodies with more or less restricted hymenial surface of the Clavarieæ and of the hemiangiocarpous families, he Thelephoreæ, Hydneæ, Polyporeæ, and Agaricineæ. Follow-

ing these must be placed the angiocarpous forms, usually known under the name of Gasteromycetes. The author suggests that these last may have been derived either from the gymnocarpous forms through the hemiangiocarpous ones, or from the Protobasidiomycetes through forms like Tulostoma. It is worthy of note that development along parallel lines in the two great groups of fungi, in consequence of the acquirement of a subterranean mode of life, should have brought about such striking similarity as is presented in the fruit bodies of the Tuberaceæ and the Hymenogastreæ.

The culture of a large number of Basidiomycetes has brought to light much that is new concerning their life-histories, and emphasizes the fact that polymorphism is by no means a characteristic of the Ascomycetes alone, or even chiefly of that group, as has been thought since the Tulasnes' classic researches. Brefeld shows that in this respect there is little to choose between the two groups. Since the basidium is merely a modified conidiophore, it might be expected that the Basidiomycetes would produce, as accessory fruit forms, unmodified and still indefinite conidiophores. And such is found to be the case with a number of forms, some of which have been already mentioned. In some Tremellineæ, Polyporeæ, and other forms, conidia have been for some time known. Another accessory fruit form which is always morphologically of strictly secondary value, although it often becomes of primary importance histologically, is the chlamydospore. These occur very frequently in cultures of Basidiomycetes, and in their simplest and commonest form are short joints cut off from the fungus threads, occurring in chains and constituting members of the old form-genus Oidium. They may often reproduce themselves indefinitely under suitable conditions without a hint of their true relationships; as in the case with the form known as *Oidium lactis*. Much less common are the more highly differentiated chlamydospores formed, like the Oidia, from joints of the mycelium, which occur in Nyctalis, Oligoporus, Fistulina, etc. These forms may be restricted to special parts of the fruit body, as to the hymenium in *Nyctalis parasitica*, or to the top of the pileus in *N. astrophora*. The

species of Brefeld's new genus, Oligoporus, have special chlamydosporic fruits distinct from their hymenial fruit body, which have been long known under the generic name Ptychogaster or Ceriomyces. In cultures of some species, notably in the case of *Fistulina hepatica*, branching aërial hyphæ produce clusters of chlamydospores almost indistinguishable from conidiophores with conidia. And in nature it becomes sometimes practically impossible to say whether a given accessory fruit form is morphologically conidial or chlamydosporic. In *Mucor racemosus* and allied forms, in which this secondary fruit form is typically present, and which Brefeld proposes to separate under the generic name Chlamydomucor, it may readily be seen that Oidia and true chlamydospores represent modifications of the same form. The chlamydospore, then, is morphologically independent of and secondary to other fruit forms, although it frequently becomes the physiological equivalent of any, and may largely suppress and replace others by being introduced into the primary cycle at any stage in the development of the fungus.

The Uredineæ have been mentioned above among the families of Protobasidiomycetes which have transversely divided basidia and lateral spores. This view of the so-called "promycelium" and "sporidia" which are developed at the germination of the "teleutospores" is an old one, which has been gaining ground in recent years, and is now emphasized by Brefeld as the most tenable and philosophical one. The three spore forms, æcidiospores, uredospores, and teleutospores, are regarded as different forms of chlamydospores, which reach their highest development in this group, and, in the teleutosporic stages of Gymnosporangium and Cronartium, look toward the differentiation of a fruit body and connect with the Auricularieæ. It is pointed out that various Autobasidiomycetes produce both Oidia and true chlamydospores, and that the intermediate sterile cells found between the latter occur also in the spore-chains of Cæoma. While the germination of the other forms is purely vegetative, the teleutospore gives rise to a basidium which is typically four-spored, the one-spored condition in Coleosporium being paralleled by that in Kneiffia of the Hydneæ. Our author believes that in this fructificative germination

lies the true character of the chlamydospore, which has been lost in other groups, leaving it as the essential feature of the Uredineæ and the related Ustilagineæ. No species which has teleutospores can be considered "incomplete," the only such species being those whose teleutospores, and therefore whose basidia, are unknown. A single other fruit form is common among the Uredineæ, the so-called "spermogonium," but its relations may better be discussed in connection with those of the similar structures which occur abundantly among the Ascomycetes.

The Ustilagineæ have been a source of much perplexity as to their relationships, although the similarity of the spore-germination in many forms to that of the Uredineæ has indicated the propriety of placing these groups near together in the system. In their formation the spores of this group closely resemble those of Ptychogaster and other chlamydospores. In germination many of them produce structures which strikingly recall the basidia and spores of the Uredineæ, and a few produce merely vegetative filaments, perhaps by degeneration from the former type; while those of a large group of forms give rise to undivided filaments, each with a whorl of conidia at its apex, representing clearly the basidia of the Autobasidiomycetes. In the great majority of these fungi the chlamydospores are the only fruit form developed, but some of them produce also conidiophores with typical conidia.

The basidia of the Ustilagineæ are distinctly more primitive than those of any of the true Basidiomycetes, in that they are much more variable in form, size, and number of spores, in all those particulars,—that is, whose definiteness constitutes the true basidium. Brefeld therefore places the group, under the name of Hemibasidii, between the Phycomycetes and the true Basidiomycetes, as a connecting link; and divides it on the basis of the two types of basidia already described, into Protohemibasidii and Autohemibasidii, corresponding to the two groups of Basidiomycetes. These two groups coincide with the two families into which the smuts have been divided by Schroeter on the basis of spore-germination, the Ustilaginei and Tilletiacei.

Passing now to the other great group of fungi, we find it also especially characterized by a particular form of reproductive

organ, the *ascus*, which has given to the order its name, Ascomycetes. This name has, however, been used in a rather more restricted sense than that of Brefeld. This is due to the fact that the characteristic of the group has been considered to be the ascus fruit, and not the ascus itself. But here, as in the Basidiomycetes, the fruit body is a secondary development within the group, subsequent to, or at most contemporary with, the differentiation of the ascus. Morphologically, the ascus is to be regarded as a reduced and definite sporangium whose form is constant, at least within the limits of the species, and whose spores, typically eight, are in most cases definite and constant in number. Intermediate conditions between the indefinite and definite extremes are distinctly to be recognized. The numerous and striking subdivisions which occur in the spores of the Ascomycetes, so useful systematically that they form the basis of Saccardo's carpologic system, are regarded by our author as germination phenomena, analogous to those seen in Dacryomyces and the Tremellineæ, which have become pushed forward into the earlier stages of spore development.

From the great body of the Ascomycetes which have a well-developed fruit body, and are called by him Carpoasci (constituting the whole of the order, according to the limitations of DeBary), Brefeld separates the forms included under Endomyces, Taphrina and Exoascus, and Ascocorticium nov. gen., as Exoasci. The members of this group, corresponding to the Tomentelleæ among the Basidiomycetes, have their asci produced, free and naked, directly from the mycelium. The Carpoasci include angiocarpous forms, the Gymnoasci, Perisporiaceæ (including Tuberaceæ), and the Pyrenomycetes; and hemiangiocarpous forms, grouped under the Hysteriaceæ and the Discomycetes. One family of the latter, the Helvellaceæ, may yet prove to deserve separation from that group. The early stages of its members are unknown, but they may be found to be truly gymnocarpous.

If we go back once more to the sporangium of Mucor, we may trace a very instructive series up to the ascus fruit of the Carpoasci. In Rhizopus we have a plant which differs from Mucor essentially in producing from a given region several

threads, some of which bear sporangia like those of Mucor (fertile threads), while others become rhizoidal (sterile threads). In Mortierella these sterile threads become woven together to form a dense capsule about the base of the fertile ones, which are long and stout. It is easy now to suppose the fertile threads reduced in length until the sporangia at their ends are withdrawn within the capsule, and just this condition is found in *Thelebolus stercoreus*, whose fruit body contains a single many-spored sporangium. From this condition a further step leads to that so familiar in the genera Sphærotheca and Podosphæra, in which the indefinite sporangium of Thelebolus has become a well-defined ascus, while the capsule is essentially unchanged. The simplest of the Carpoasci are the Gymnoasci, which have a well-marked ascus, but whose capsule consists of very loosely entangled hyphæ. Another line may be traced from some Choanephora-like form, with sporangia and conidia, through the new plant described as *Ascoidea rubescens*, which produces ascus-like sporangia and conidia, to the numerous conidia-bearing Ascomycetes.

Having seen how all of the primary fruit forms of the higher fungi, the ascus, the conidium, and the basidium, are derivable from the simple sporangium of the Phycomycetes, we may summarize the whole graphically as follows:

Sporangium.
(Mucor.)

Sporangium. — (Thamnidium.) — Sporangiolum.

Sporangium. (Rhizopus.) (Mortierella.)		Closed Spor'm.=Conidium. (Chætocladium.)
Ascus-like Spor'm. (Thelebolus.)	Ascus-like Spor'm. and Conidium. (Ascoidea.)	Basid'-like Conidiophore. (Ustilagineæ.)
Ascus. (Ascomycetes.)	Ascus and Conidium. (Ascomyc. with conid.)	Basidium. (Basidiomycetes.)

In the study of more than 400 Ascomycetes there has been found the greatest diversity in the time of the appearance of the ascus in the fruit body, and in its relations to the tissue of threads composing that body. In some cases the asci and the intermingled sterile threads, or paraphyses, arise as branches of the same hyphæ; or, again, the two may rise from separate hyphal systems which are differentiated early and remain structurally distinct. This distinction is never seen in the Basidiomycetes and is not to be expected, since none of their ancestral Phycomycetous forms show any such differentiation as has been described in Rhizopus and Mortierella, which are believed to represent ancestral forms of the Ascomycetes. Brefeld points out that it is this differentiation of fertile and sterile threads which has given rise to the doctrine of the sexuality of the Ascomycetes of which DeBary has been the especial champion. He contends elaborately and with the strongest emphasis that there exists no proof whatever that the so-called "ascogonium" and "pollinodium" observed in certain Carpoasci are of any sexual significance. This view, he maintains, has been reached deductively, and not inductively; by inference, and not by proof. The analogy of the sexual organs of the Florideæ has exerted a strong influence on the interpretation of the significance of the structures in question and of the so-called "spermatia," to be discussed later; yet the Florideæ and the Ascomycetes are as little related as any two groups of Thallophytes. The fusion of the initial fertile filament with one or more of the surrounding sterile filaments has no more significanc than any of the hyphal fusions, so common among fungi. It is quite as reasonable to suppose that, in the great number of forms in which this early differentiation is not observed, it has become obscured or lost in the bewildering tangle of hyphæ, as that typically sexual fungi have lost their sexual organs by abortion.

Two fungi, Thelebolus and Ascoidea, have been mentioned as having ascus-like sporangia, and as holding an intermediate place between the Phycomycetes and the true Ascomycetes. With these should be mentioned a third genus, Protomyces. This genus has been recognized as related to the Ustilagineæ, since its spores are developed from the hyphæ in much the same manner

as those of the latter group, although they germinate differently. Like those of the Ustilagineæ, its spores, as ordinarily observed, must be regarded as chlamydospores, and, like most of those, their germination is fructificative; but the product of germination is a sporangium which shows a tendency towards the more definite form of the ascus. In this view Brefeld adopts the early explanation of DeBary, the first student of the genus, which was afterwards reconsidered by him. These three intermediate forms hold the same relations to the Ascomycetes as do the Ustilagineæ to the Basidiomycetes, and similarly they are grouped together under the name Hemiasci; Ascoidea and Protomyces, with naked sporangia, constitute the Exohemiasci; and Thelebolus, with its well-developed fruit body, is the type of the Carpohemiasci. These two intermediate groups, the Hemiasci and the Hemibasidii, are made to constitute, under the name Mesomycetes, one of the three great divisions of the fungi, coördinate with the Phycomycetes and the Mycomycetes. This last group includes the true Basidiomycetes and Ascomycetes, the "higher fungi."

Of the accessory fruit forms, chlamydospores are not common among the Ascomycetes, though both Oidia and the typical form may occur. Unquestionable specimens of the latter are known in the Sepedonium and Mycogone stages of those parasites of "toadstools" and similar fungi which belong to the genus Hypomyces. While, theoretically, there is no reason why unmodified sporangia or conidiophores modified into basidia should not occur as accessory forms in the Ascomycetes, they have, in fact, never been observed; but the ordinary conidiophores are very abundant,—much more so than in the Basidiomycetes. These may arise from retrograde development of sporangia still left after the differentiation of the asci; or they may represent the conidia of Choanephora-like forms whose sporangia have become asci. They are formed either by budding from the ascospores at germination, after or even before their escape from the ascus; by abstriction from the germ-tube directly; or on distinct conidiophores. The budding of conidia from the ascospore recalls the similar cases among the lower Basidiomycetes; but it may be

forced a step farther back and take place within the ascus, giving to it an indefinitely polysporic appearance. Conidia of this type usually increase freely by yeast-like budding, like those of the Ustilagineæ; and, excepting those of the Taphrinæ, they usually develop readily, under suitable conditions, into filaments. The less specialized conidiophores have their conidia scattered over their entire length, and a gradual advance may be traced from this form to those whose conidia are wholly restricted to their tips.

Besides occurring separately, conidiophores are found grouped into dense clusters, such as have been described under the name Coremium, or into more extensive, compact "stromata." In simpler cases the surfaces of these stromata are flat; but they may be ridged or folded, and a fold may increase in depth until its edges meet, and a closed cavity is the result. Such a series may be traced in Nectria and its allied genera of the Hypocreaceæ. Closed conidial fruits which may be supposed to have originated in this way are very common among the Ascomycetes, and have long been known under the name *pycnidia*. They are known among the Basidiomycetes only in the Uredineæ and the new Tremellaceous genus Craterocella. In their development pycnidia present two types. They originate by the interweaving of previously formed threads (symphyogenic), or by the fusion of newly formed threads into a parenchymatous mass (meristogenic). Within the cavity of the pycnidium spores may be formed from all the cells or only from the terminal cells of the spore threads, just as in the case of free conidiophores. Two distinct forms of conidia may be borne on the same conidiophore or within the same pycnidium; or they may be separated, and so lead to distinct conidial or pycnidial forms on the same plant.

A fruit form very common among the Ascomycetes and the Uredineæ is that which has been known as the *spermogonium*, on account of its supposed sexual nature. This organ is structurally like the pycnidium; but the spore-like bodies developed in its cavity have been supposed, chiefly from the analogy of the spermatia of the Florideæ, on account of their minute size and the fact that they had never been seen to germinate, to be male sexual elements. But Brefeld and his pupil, Möller, have suc-

ceeded not only in observing the germination of these bodies, but in raising from them fertile mycelia, thus clearly proving them to be a form of pycnidial conidia with somewhat weakened or reduced germinative power. Thus falls another supposed support of the sexual theory of the Ascomycetes.

The conditions governing the development of the Ascomycetes are very little known. The ascus usually closes the cycle of development as the most perfect and most highly differentiated fruit form. In artificial cultures of fungi of this order it is usually found that conidial and pycnidial spores yield the fruit form which produced them, and rarely give rise to the ascus-fruit.

From what has been said above, it will be seen that all the more specialized fungi are considered to be descendants of forms identical with, or similar to, living Phycomycetous species, and to have retained none of their sexual characters, since all their primary fruit forms have been derived from, and are referable back to, the Zygomycetous sporangium. We may summarize the points brought out and the relationships indicated by means of the following tabular view :

A. PHYCOMYCETES.

I. ZYGOMYCETES.				II. OÖMYCETES.	
Exosporeæ.			*Carposporeæ.*		
With Sporan.	With Sporang. and Conid.	With Conidia.		With Sporang. or Conidia.	With Conidia.
Mucor.	Choanephora.	Chætocladium.	Rhizopus.	Peronosporeæ.	Entomophthoreæ.
Thamnidium.		Piptocephalis.	Mortierella.	Saprolegnieæ.	
				Chytridieæ.	

B. MESOMYCETES.

III. HEMIASCI.			IV. HEMIBASIDII.	
Exohemiasci.		*Carpohemiasci.*	*Protohemibasidii.*	*Autohemibasidii.*
Ascoidea.	Protomyces.	Thelebolus.	Ustilagineæ.	Tilletieæ.

C. MYCOMYCETES.

V. ASCOMYCETES.			VI. BASIDIOMYCETES.				
Exoasci.	*Carpoasci.*		*Protobasidiomycetes.*		*Autobasidiomycetes.*		
	Angiocarpous.	Hemiangiocarpous.	Gymnocarpous.	Angiocarpous.	Angiocarpous.	Gymnocarpous.	Hemiangiocarpous.
Endomyces.	Gymnoasceæ.	Hysterieæ.	Uredineæ.	Pilacreæ.	Lycoperdaceæ.	Dacryomyceteæ.	Thelephoreæ.
Taphrina.	Perisporieæ.	Discomycetes.	Auricularieæ.		Nidularieæ.	Clavarieæ.	Hydneæ.
Ascocorticium.	Pyrenomycetes.		Tremellineæ.		Phalloideæ.	Tomentelleæ.	Polyporeæ.
					Hymenogastreæ.		Agaricineæ.

Such in outline are the results to which Prof. Brefeld has been led by the long and careful study of a remarkably large number of fungi of all groups and in all stages, with the assistance of the most elaborate and precise culture methods yet devised. In all his work he has had the help of trained assistants, and in that on Ascomycetes has had also the collaboration of Dr. Franz von Tavel, of Berne, whose previous researches on the development of the Pyrenomycetes are well known. One need not accept these conclusions in all their details in order to recognize the fact that they are the result of the application of a keen morphological insight to a much wider and fuller series of observations than has been at the command of any previous writer. We may regret that the author finds it necessary to introduce so much of a personal and polemic nature into some of his discussions, especially that concerning the sexuality of the Ascomycetes, or to treat so unceremoniously his former master, DeBary, and others of that school who have antagonized and criticised his views; yet it must be remembered that the provocation has sometimes been very great.

But, after all is said, we have in this characteristic work of a remarkable man a series of memoirs which must always remain classic and a prime authority for the student of the morphology of the fungi, both as the record of a great number of new facts, and as the first statement of a new and consistent comparative morphology.

Amherst, Mass.

ROCKY MOUNTAIN RHIZOPODS.

BY EUGENE PENARD, SC.DR.

DURING a stay which I made this year in the mountains of the state of Colorado I gave some of my time to the study of the fresh-water Rhizopods, comparing them with those I had observed in various regions of Europe. I should like to give here the results of my comparisons.

All the organisms which are treated of in this paper have been found in the neighborhood of Caribou, a small mining town north of Boulder, and about 10,000 feet above the level of the sea. At this altitude Rhizopods are still numerous, as Leidy has shown in his remarkable work on the fresh-water Rhizopods of North America. He found them abundant in the Uinta Mountains, Wyoming, at 10,000 feet,—the highest altitude, I believe, at which these organisms have as yet been found. However, as will be seen later, my gatherings at 12,000 feet have been very productive, which is after all not to be wondered at, knowing the very great capacity of these organisms for resisting either cold or heat, or any other disturbing element. In fact, they can be expected to be found everywhere, provided there are mosses and humidity, and if I have not found them higher (except one species, *Difflugia constricta*, at 12,500 feet), it is only because the ground was unfavorable to the presence of quiet water, and that my investigations at these higher altitudes have been very few.

I have no intention to speak about the organization and physiology of these organisms. Leidy, in his beautiful work, has treated the subject at length. I would simply like to give a list of the species I have found in the Rocky Mountains, adding some remarks about a few of them, and finishing with some observations on the structure of the shell in these animals. This structure is not very well known in most of the species; and as I have in these latter years accumulated a good many observations in this connection, I venture to detail them here, in the hope that they will prove of some interest.

I give now the list of the species I collected in various bogs or swampy grounds in the neighborhood of Caribou, and at a height varying from 10,000 to 10,500 feet. The animals were mostly found among mosses and sphagnum, whose presence at that altitude is itself remarkable.

Amœba limax Dujardin, *Amœba verrucosa* Ehrenberg-Leidy, *Difflugia pyriformis* Perty, *Difflugia arcula* Leidy, *Difflugia lucida* Penard, *Difflugia fallax* Penard, *Difflugia bacillifera* Penard, *Difflugia constricta* Ehrenberg, *Centropyxis aculeata* Stein, *Arcella vulgaris* Ehrenberg, *Arcella vulgaris* var. *angulosa* Leidy, *Arcella discoides* Ehrenberg, *Arcella microstoma* Penard, *Quadrula symmetrica* Schulze, *Lecquereusia jurassica* Schlumberger, *Nebela collaris* Leidy, *Nebela longicollis* Penard, *Nebela tubulosa* Penard, *Nebela dentistoma* Penard, *Heleopera rosea* Penard, *Assulina minor* Penard, *Pseudochlamys patella* Claparède and Lachmann, *Cryptodifflugia oviformis* Penard, *Cyphoderia margaritacea* Schlumberger, *Euglypha alveolata* Dujardin, *Euglypha ciliata* Leidy, *Euglypha cristata* Leidy, *Euglypha compressa* Carter, *Euglypha lævis* Perty, *Sphenoderia dentata* Penard, *Trinema lineare* Penard, *Trinema enchelys* Leidy, *Trinema enchelys* var. *galeatum* Penard, *Trinema complanatum* Penard, *Corythion dubium* Taranck, *Corythion pulchellum* Penard.

All these species, which did not differ in any particular from those which have been described from Europe, India, Australia, or from various parts of the United States, were generally found represented by very numerous individuals. Yet sometimes a very few were present in a given locality, or again some given species, entirely absent from one place, was abundant in another and very near one.

But there are a few of these species on which I should like to write at some length:

Difflugia pyriformis Perty.—This species is extremely variable; or rather, if I may be allowed to express a personal opinion, should be and will be one day decomposed into a large number of distinct specific forms, some of which again will show an undeniable tendency towards a great variability. In fact, my observations, which have been protracted for several years and made on

more than 200 gatherings in various localities of Europe, have brought me to the conclusion that many autonomous species of Rhizopods have acquired in their evolution and in independent ways the form *pyriformis*. Indeed, this simple and efficient shell is exactly the kind one would expect to be formed by an organism in its first stages of evolution from the amœba condition to that of a testacean Rhizopod.[1]

However it may be, if the following conditions are considered sufficient to determine a species:

1. The general characters of the shell (form, size, structure, composition) are sharp and constant in a form A, though not far distant from those of other forms B, C, etc.

2. In the state of copulation (conjugation) A is always seen together with A, and never with B or C, etc.

3. In certain localities A is to be found alone, whilst B or C are not present.

4. Intermediate forms between A and B, or C, etc., do not exist, or at least are very exceptional cases.

If, I repeat, these characters, accumulating in one and the same form, are considered sufficient to make of that form a distinct species, then it would be easy to separate the *Difflugia pyriformis* Perty in a dozen at least of such autonomous species.

Now I have observed at Caribou several different forms of *Diff. pyriformis*, and especially one that I found very abundant in several localities deserves a particular mention. With the typical form of the species, and built of angular grains of quartz, sometimes with admixture of a few diatoms, its shell was remarkable by virtue of a large amount of brownish matter (oxide of iron), dissolved in a chitinoid magma, which generally formed a brownish substratum or inside lining to the shell. Now we must observe that in those species of Difflugia whose shells are normally and essentially formed of sand particles, the proportion of

[1] At the same time, and whilst this explanation may be good in a general way, I am inclined to think that some of the forms or species so formed would still be in an unfixed state, and might be compared to such forms of vegetable life as Rosa, Rubus, Hieracium, which with their many varieties constitute the bliss of some, but the despair of most, collecting botanists.

chitinoid matter is normally very slight, and this particular Difflugia is an interesting exception.

Quadrula symmetrica Schulze.—I have found this beautiful species abundantly in most of my gatherings, but mostly represented by very small-sized individuals (length 0.040–0.060 mm.). On the contrary, in one single locality the species was to be found under what might be called a giant form (length 0.100–0.150 mm.), which presented this other peculiarity, that the square plates composing the shell, instead of being disposed, as in the typical form, in a high degree of symmetry, showed great disorder in their arrangement, and very often overlapped each other. The sides of the shell, instead of looking like a tolerably continuous curve, appeared like a series of broken short lines. These two varieties, if they must be considered as such (in my opinion, they are more than varieties), were very sharply distinct, and I have not seen any transitional forms.

Nebela collaris Leidy.—This species also was represented at Caribou by two very distinct forms: first the typical one (forma *genuina* Taranck), not very abundant as a rule, and totally absent in some places; then another form, or dwarf variety, extremely abundant, and often to be found quite alone in some localities. This latter form agrees perfectly with a variety which Leidy has figured in his great treatise (Pl. XXII., Figs. 11, 12, 16).

Nebela longicollis Penard.—Rather abundant in nearly all my gatherings. The species is very different from the preceding; yet the form I found at Caribou could hardly be referred to the *Nebela longicollis* such as I described it in 1890[2] (which appears to be the same as *Neb. barbata*,—Leidy, Pl. XXIV., Figs. 14–17). It agrees, on the contrary, very well with two shells figured by Leidy (Pl. XXIV., Figs. 18, 19) as "intermediate in character to *Neb. barbata* and *Neb. collaris*," and at the same time shows relations to the form that I called *lageniformis*. I mention here the Caribou form under the name *longicollis*, being of opinion that *Neb. barbata* and the two Figs. 18 and 19 of Leidy refer to one

[2] Etudes sur les Rhizopodes d'eau douce. Mémoires de la Société de Physique et d'Histoire naturelle de Genéve, 1890. All the species mentioned in this paper, and which bear my name, have been described in the same work.

and the same species; and at the same time I avoid the use of the name *barbata* because it appears to me to be the result of a confusion of the author, who took foreign and parasitic elements for normal covering setæ.

As already stated, those species found at 10,000 feet did not as rule show any difference from those described from the plains or in other continents, and showed the same relative abundance of individuals. Yet it will not be without interest to refer here to the utter absence of several forms of Rhizopods which one would have expected to find, and among which I shall only cite *Hyalosphenia papilio* Leidy, *Nebela flabellulum* Leidy, and *Assulina semilunum* Leidy. *Hyalosphenia papilio* is a very constant inhabitant of sphagnum-mosses; I do not think I ever found in Europe a single bunch of sphagnum that was not replete with it. *Nebela flabellulum*, according to my experience, mostly affects the mosses in the woods, yet it is very frequently found in sphagnum. As for *Assulina semilunum*, its place was taken at Caribou by the species I have called *Assulina minor*. This latter form might be considered a dwarf variety of the former, and in fact must have been so regarded by Leidy, who has figured two shells belonging apparently to it (Pl. XXXVII., Figs. 15 and 26). But besides the considerable and absolutely constant difference in size, there are others characters which decided me to make of it a distinct species, and the fact that at Caribou this form was absolutely the only one to be met with would constitute, if necessary, further proof of the correctness of my decision.

I come now to the list of the species that I found in the mosses of a swampy pasture-ground, under the summit of the hill called Bald Mountain, and about 12,000 feet above the level of the sea. Sphagnum does not grow at so high an altitude, and consequently was not represented among these mosses: *Amoeba* ———, sp. nov.? *Difflugia pyriformis* Perty (small variety), *Difflugia constricta* Ehrenberg, *Difflugia rubescens*, sp. nov., *Nebela collaris* Leidy (and small variety), *Nebela longicollis* Penard, *Nebela dentistoma* Penard, *Arcella microstoma* Penard, *Pseudochlamys patella* Clap. and Lachmann, *Heleopera rosea* Penard.

All these species were to be found in very numerous individuals; in fact, as numerous as 2,000 feet lower down. Yet to that list ought to be added: *Euglypha ciliata* Leidy, one specimen; *Trinema lineare* Penard, one specimen; *Assulina minor* Penard, a very few specimens.

An interesting fact seems to me to be that, with the exception of the very few individuals belonging to the three latter species, which I found after much exertion among hundreds and hundreds of other rhizopods, all the species mentioned in the list belong to the section of the Rhizopoda known as "Lobosa,"—*i. e.*, with broad and blunt pseudopodia. The section "Filosa," [3] including those Rhizopods with filiform pseudopodia (Euglypha, Trinema, Sphenoderia, etc.), so rich in species, and yet more so in individuals, which generally swarm everywhere and outnumber the Lobosa, have been found to be practically absent at a height of 12,000 feet. My observations, which concern only a single locality, are not sufficient to enable me to draw from that absence any certain conclusions; yet, at any rate, they seem to show a remarkable difference in the vital resistance between those two great divisions of fresh-water Rhizopods.

Among the species mentioned in the list I find two of them which must be dealt with at some length:

Difflugia rubescens, sp. nov.—Very likely this form has been seen by Leidy; indeed, he figures two shells which I think must be referred to this organism (Pl. x., Figs. 24, 25) as belonging to *Difflugia pyriformis*, and with the statement "with brown endosarc." But we have most certainly here a distinct species, which I shall call *Difflugia rubescens*. It was very abundant. I have examined several hundreds of specimens, which have all proved to be remarkably constant in form, size, and structure. The shell, pyriform, not compressed, not quite twice as long as broad (length, 0.030–0.035 mm.), consists first of a pellicle of clear chitinoid material, always covered with diatoms. These

[3] Leidy separates the fresh-water Rhizopods into two great divisions, Lobosa and Filosa. This corresponds, in fact, to two very natural groups; yet I must mention that a few Rhizopods (Cyphoderia, Cryptodifflugia, some Pseudodifflugia, and some Amœbæ) show intermediate characters in their pseudopodia, which are capable of passing from one form to another in a comparatively very short time.

diatoms, though belonging always to small species, occupy, each of them, a relatively large place on the shell, and give rise to a very general deformation of its otherwise regular contours (as indicated by the chitinoid substratum). Sometimes among the diatoms are to be found one or two quartzose grains. In the main the structure of the shell is the same as that of *Diff. bacillifera* Penard, but the form and size are different. Besides,—and this is the most important character of the species,—the plasma has normally and constantly a beautiful brick-red color, resembling that, for instance, of *Vampirella lateritia* Fresenius. It would have been interesting to investigate if in this species the pseudopodia present in their outstretched state the general colorization of the plasma. Unhappily all the animals were at the time of examination retracted in their shell and in course of encystment; and in spite of observations extending over a space of more than two weeks, I have never noticed an extended pseudopod. Yet from analogy with what I have seen in *Vampirella lateritia*, and in an Heliozoon (*Artodiscus saltus* Penard), I am inclined to think that the pseudopodia, or at least their terminal parts, must be deprived of colored matter. It is perhaps not useless to add that the red color had certainly nothing to do with foreign matter, algæ or digested products. The nucleus, generally invisible, was nevertheless sometimes quite distinct; acetic acid brought it easily to view. It did not differ in any respect from the nuclei of other Rhizopods. No contractile vesicle was present, owing very likely to the encysted state of the plasma.

Amœba ———, sp. nov.?—This amœba was rather abundant, and very constant in its form and organization; yet I have not followed it long enough to describe it as a new species. It was very small (diam., 0.010 mm., without the pseudopodia), and consisted of a spherical, clear body, normally covered by a layer of greenish, but not shining, transparent globules, finely punctulate, about 0.002 mm. in size, and forming a continuous envelope. These globules were apparently of protoplasmic nature, and a product of secretion of the animal itself. They were mostly associated with a small number of shining, irregular particles of what appeared to be amorphous siliceous matter. Sometimes, how-

ever, these particles were present in such abundance that they built up the greater part of the envelope and took the place of the protoplasmic globules, which were then only few in number. The pseudopodia were mostly much elongated,—four or five times as long as the diameter of the animal, or more,—very slender, and gradually tapering from the base to the summit, which was filiform. They were straight, rigid, few in number (about half a dozen), and were capable of radiating in every direction, while the animal walked on their points. At other times the animal would crawl along the grounds, slightly compressed at its point of contact, and then the pseudopodia would be shorter, less rigid, and flattened.

The nucleus and the contractile vacuole could not be seen, being hidden behind the envelope of globules. In short, this species recalled very much the *Amœba radiosa*, from which it was distinguished by its constant protective envelope, as well as by its very much smaller size.

Having in the preceding pages given a description of the Rhizopods I found in the Rocky Mountains, I should like to present a few general remarks on the structure of the shell in these animals.

These organisms have sometimes been divided into "Nuda" and "Testacea." There exist some transitional species, whose plasma is simply hardened on most of its surface, or covered with protective granules, or is even differentiated into a genuine double-contoured, supple, and membranous covering. But in what follows I shall only treat of the true "Testacea," with a solid and rigid shell. The Testacea constitute by far the greater part of fresh-water Rhizopods.

The nature of the shell in these beings is as yet little known. Generally speaking, and after consulting most of the works that have been written on these animals, one arrives at the following conclusion: The shell of the fresh-water Rhizopods is chitinoid, often with an admixture, in various proportions, of siliceous elements (sand grains, diatoms, scales).

My observations, which have been made on nearly all the known species, allow me to modify the preceding opinion, and to

present the following statement, which holds good for all hard-shelled Rhizopods:

The shell of fresh-water Rhizopods is composed of two elements: (*a*) Silica, always in the form of detached pieces, and forming most of the mass of the shell; (*b*) chitinoid, or chitino-siliceous matter, serving as a substratum or soldering magma.

(*a*) SILICA.

Silica is first found represented by fine particles of sand. In this state it generally constitutes nearly the whole of the shell in the genus Difflugia, especially in the species of this genus which frequent the bottoms of rivers or clear-water ponds. In these latter species the amount of chitinoid matter is so small as to be scarcely discernible, and the shells, when compressed, show hardly any elasticity, their various elements or sand particles being easily disaggregated.

Besides being found in Difflugias *sensu stricto* (denoting thereby those species of the genus whose shells are normally built of quartz grains), silica in the state of sand particles can be found in many Rhizopods (Difflugia in part, Centropyxis, Heleopera, etc.), but in these cases generally forms a part only, and not an important one, in the constitution of the shell.

I must mention here a very curious fact, to which I called attention in 1880, and which the observations I have since made at Geneva on a new interesting species have shown me to be of more frequent occurrence than I at that time thought; namely, that in certain species (*Diff. lucida*, *Diff. fallax*) the shell, very much like that of one built up of true sand particles, is in reality covered on its entire surface with amorphous siliceous elements, transparent, colorless, often rather flattened, less angular than real stones, a product of the animal itself, and constituting in these species a remarkable case of mimicry.

Very often, and in numerous species, silica is to be found as amorphous plates or scales, seldom alone (*Heleopera rosea*), more often mixed up with sand grains or other elements (diatoms).

Diatoms are very frequent in a great number of species (Difflugia i.p., Pseudodifflugia, Centropyxis, Lecquereusia, Nebela, etc.). It

is very seldom that they constitute normally the total covering of the shell (*Diff. bacillifera, Diff. rubescens*); yet, even in species where as a rule these algæ only make up a part of the envelope, one may always expect to find isolated specimens where they constitute the total covering.

All the siliceous elements which I have until now mentioned are irregular, either in their form or in their relative sizes on the shell; but there exist a whole series of genera where these elements are conspicuous by their geometrically regular form. However, before speaking of these I shall mention some forms which occupy a somewhat intermediate position. They belong to the family of Nebelidæ. In this family the siliceous elements are represented by regular circular or oval discs, contiguous with each other and covering the whole shell. Sometimes all these discs are very nearly of the same size all over the shell, at other times large ones are mixed up with very much smaller ones. These discs are generally very conspicuous, but in the genus Hyalosphenia and in some Nebela they cannot be seen, and the shell looks as if it were composed of a continuous chitinoid membrane. Yet in these species it is most probable that the discs really exist, but are very thin, and hidden in the abundant chitino-siliceous matter of the envelope.

We now come to those genera in which the siliceous scales have regular forms and are symmetrically disposed. The genus Quadrula is remarkable for its square, colorless scales, touching each other with their borders and arranged in regular series. In the numerous species of Euglypha the plates are oval, sometimes circular, seldom cordiform, but always perfect in their shape, disposed in diagonal series over the whole shell, and slightly overlapping each other. The circular or oval plates of Sphenoderia, Trinema, Placocysta, are also perfect; but in some species, owing to the form of the shell, they may vary very much in size in different regions of the shell. In the *Assulina semilunum* the plates are elongated, very thick, and often incline to a slight asymmetry. In *Corythium dubium* they are still all alike, but have more the shape of an elongated rectangle.

(*b*) CEMENTING MATTER.

In all testaceous Rhizopods the siliceous elements are cemented by or sometimes lie on a substance which may be called chitinoid, or rather chitino-siliceous. This matter, often quite transparent and colorless, but sometimes colored,—yellow, dark purple in some Arcellas, pink in *Heleopera rosea*, chocolate-brown in Assulina,—is more or less abundant according to the species. Nearly absent in the Difflugias *sensu stricto*, and in very small quantity in Euglypha, Quadrula, etc., it varies considerably in thickness in the series of species, generally making an internal varnish to the inner side of the shells, thence penetrating between the plates or other siliceous elements, sometimes overlapping them at the outside, and forming as it were relief veins or exudation droplets. But it never makes up the entire mass of the shell, and it is only very seldom (Hyalosphenia) that it constitutes the principal mass of the same.

I have called this matter chitino-siliceous, because, in fact, I am inclined to consider it as consisting of a mixture of chitinoid matter and of an infinity of extremely small siliceous particles imbedded in the magma. This is but a supposition, yet it may perhaps give an explanation of the following facts: This matter, in the pure state and without admixture of foreign elements, as it occurs for instance in the genus Centropyxis, resists the action of red heat (blow-pipe) or of cold, concentrated sulphuric acid, but disappears completely in boiling sulphuric acid. This I would explain by saying that in both cases the chitinoid matter is dissolved, but that whilst by mere heating the siliceous particles becomes soldered to each other during the process, the convection currents in the boiling sulphuric acid disperse them. The following experiment explaining the relations between the plates of the shell on the one hand and the connecting matter on the other, may at any rate give some probability to the explanation just given concerning the chitinoid matrix: I have found that the shells of all the testaceous Rhizopods resist both red heat (blow-pipe) and cold, concentrated sulphuric acid, but that this acid when boiling, after separating the plates from each other,

disperses them so widely in every direction that it is generally impossible to find them again. Yet, if one takes the precaution to isolate a shell (say Euglypha) in a very small drop of acid, one finds after the action of the boiling acid all the plates again; but they are dissociated from each other, and in a little heap. In this case the chitinoid matter is gone, and has left only the pure siliceous plates.

At the same time, it must be added that in some species the cementing matter seems to be purely chitinoid in some regions of the shell; for instance, about the mouth in *Sphenoderia dentata*, *Corythium pulchellum*, and others.

There are two genera of which I have not yet spoken, and concerning which I should like to say a few words,—namely, Cyphoderia and Arcella.

The shell of Cyphoderia, with its elegant covering of small, regular, hexagonal alveoli, is very currently considered to be made up, first, of an internal, brownish, chitinous pellicle, and then of an external envelope, itself consisting of hexagonal, chitinous prisms. The experiments I made at Geneva on this species have shown me that it is not so. In reality, the internal chitinoid pellicle is covered over its whole surface with small discs, or rather cylinders, consisting of pure silica. These I was able to isolate and examine on all their faces. They are circular in section, about one-third larger in diameter than in height, flat, or very little excavated on their upper and lower faces, and have altogether the form of fish vertebræ. Their diameter is in the bigger shells (var. *major*) about 0.002 mm.; their size is uniform over the whole shell. They are disposed with a wonderful regularity, touching each other by the borders, and cemented together by the chitinoid matter which penetrates into the interstices and often flows out to the outside. The appearance of hexagonal alveoli is a result of the juxtaposition of all these small cylinders and of the interposition of the cementing matter.

As for the shell in Arcella, I feel confident that it is analogous to that of Cyphoderia; but the siliceous elements are very much smaller, and the experiments I have made have not been decisive. Yet I have seen on broken shells that the lines of fracture were

covered with denticulations of uniform size, as they are seen on broken shells of Cyphoderia, each tooth representing a siliceous disc. I ascertained also that these shells resist very well a red heat, but after the action of boiling sulphuric acid I was not able to find the discs with certainty.

As for the origin of all these regular siliceous elements in Rhizopods, it is well known now that it must be looked for in the plasma itself. The animal has the power of secreting these siliceous plates in the very inside of its body, and in many species (Quadrula, Euglypha, etc., etc.) these plates can be seen very frequently in the plasma, either lying there without any order, or, on the contrary, disposed in regular layers. I will mention here that the species Cyphoderia has always been described as very generally containing, especially at the posterior part of its plasma, a considerable number of shining, very refractive grains, that were supposed to be starch or excretion granules. Now I have been able to isolate these granules, and to satisfy myself that they resist both red heat and boiling sulphuric acid,—a fact which proves them to be siliceous, and to represent nothing but plates in course of formation, destined ultimately to build up another shell. It is well known, indeed, that these reserve plates (Reserveplättchen), as they have been called, will not be of any use to the animal that formed them, but serve to make up a shell for a new animal. An individual A, for instance, full of reserve plates, expels these plates through its mouth, together with some of its own plasma. The whole plasma becomes highly vacuolated, and thus augments in volume; the expelled portion, still attached to the mouth of the parent, takes the form of the species, and the plates are disposed as an outer covering, and in the most beautiful order.

These reserve plates are certainly a product of the animal itself, which has thus the power of secreting silica. Besides, from very numerous observations on shells (especially Nebela) on which all transitions are to be seen from perfect diatom cases to very simple rods that have lost all precise form, it appears certain to me that, as Wallace suggested, the plasma of Rhizopods has the power of deforming and partly dissolving the shells of diatoms.

Sometimes, however, some of the investing elements can be seen which must have been directiy deposited on the shell from the outside,—inorganic particles and diatoms which are much too large ever to have gone through the mouth of an individual belonging to the species.[4] At other times, again, the whole shell seems to have been formed by external apposition, as in many specimens of *Pseudodifflugia hemisphærica* which I have examined, in which nearly the whole of the shell was made of diatoms, still containing their plasma and their yellowish or brown chromatophores.

Before concluding, I would emphasize the constant dislike of Rhizopods for limestone. Not only are limestone countries always poor in Rhizopods, as Leidy showed in 1879, but even species that easily endure the presence of lime will never use any particle of it for the building of their shells. In the spring of this year I examined numerous species of Difflugia which inhabited the muddy bottom of Geneva. This mud, under the microscope, is seen to be composed of a mixture in nearly equal proportions of very fine particles of quartz and transparent limestone. A little chip of limestone, two- or three-thousandths of a millimeter in diameter, often very closely resembles another such chip of quartz. Without a careful examination a professional observer might easily be deceived; but a Difflugia is not, and will always choose quartz particles for the building materials of its shell.[5]

[4] Indeed, in some forms (*Difflugia bacillifera, Diff. rubescens*) this seems to be the only way in which the shell can be built.

[5] Besides these Rhizopods, I have found, of course, mixed with them, many other organisms,—Infusoria, Flagellata, Rotifers, Nematodes, etc. Of these I will cite only two Cilioflagellata, *Glenodinium cinctum* and *Peridinium tabulatum*, and three Heliozoa, *Actinophrys sol, Heterophrys* —— ? *Acanthocystis myriospina* Penard ? (*Acant.* —— with simple spines, Leidy); fine specimens of this latter were abundant at 12,000 feet

LIFE-HISTORY OF THE VERMILION-SPOTTED NEWT (*Diemyctylus viridescens* Raf.)[1] [2]

BY SIMON HENRY GAGE.

THE working out of the complete life-history of this newt hsa extended from 1819–1820, when Say and Rafinesque first considered it, until the present year (1891). During this period of seventy-two years it has been the subject of numerous investigations; but from the striking changes in coloration, habit, and structure passed through in its various stages of development it has proved unusually puzzling to the naturalist and physiologist. The phases in its life-history are briefly as follows:

1. The ova are laid in water, and give rise to larvæ with well-developed gills. In course of development these larvæ assume the vermilion spots and general viridescent coloration of the adult.

2. The gills are absorbed, the viridescent coloration changes to a yellowish-red of varying brightness, the vermilion spots remain, the oral epithelium changes from a stratified non-ciliated to a ciliated epithelium, and the respiration and life become wholly terrestrial.

3. In from two to three years the newt changes its red for a viridescent coloration, returns to the water, loses its ciliated and regains a stratified non-ciliated oral epithelium, and reassumes a partial aquatic respiration, and during the remainder of its life is properly an aquatic form.

Historical.—In Vol. I. of the *American Journal of Science*, Say ('19, p. 264) under the name of *Salamandra punctata* Gml. gives

[1] Synonymy, modified from Cope ('87, p. 207): *Triturus* (*Diemyctylus*) *viridescens* Raf. ('20), *Triturus* (*Notophthalmus*) *miniatus* Raf. ('20), *Salamandra punctata* Gml. Say ('19, p. 264), *Salamandra dorsalis* Harlan ('27, Vol. VI., p. 101), *Salamandra symmetrica* Harlan ('25, Vol. V., p. 158), *Salamandra millepunctata* Storer ('38, Vol. III., p. 60), *Salamandra greenii* Gray (Griff. A. K., IX. Syn., p. 107), *Salamandra coccinea* DeKay ('42, p. 81), *Triton dorsalis* Holbr. ('42, Vol. V., p. 77), *Triton millepunctatus* DeKay ('42, p. 84), *Notophthalmus viridescens* Baird ('50, p. 264), *Notophthalmus miniatus* Baird ('50, p. 284), *Triton punctatissimus* Dum. Bibr. ('41, p. 154), *Triton symmetricus* Dum. Bibr. ('41, p. 154), *Diemyctylus miniatus* Hallowell ('56, pp. 6–11), Kelley ('78, p. 399), *Triton viridescens* Strauch ('70, p. 50), *Molge viridescens* Boulanger ('82, p. 21).

a very good description of the viridescent form, and near the end adds: "The younger specimens vary considerably in being on many parts of the body destitute of black punctures, and in having the dorsal and ventral color of the same pale orange. It is decidedly aquatic." As the last sentence follows without explanation, it apparently applies to both the young and the old, and is rather confusing.

The year following Rafinesque, in placing several Urodeles in his new genus Triturus, remarks with reference to the adult Diemyctylus: "It must form a peculiar subgenus Diemyctylus"; and with reference to the red form he says: "It has almost the characters of the subgenus Diemyctylus, but differs from it by having the toes of the fore feet free and unequal, the lateral ones much shorter, whence it may form another subgenus, Notophthalmus." That is, the adult viridescent and the immature red form were by Rafinesque placed in different genera.

This was continued by some authors, as DeKay; by others the two were placed in the same genus, although considered specifically distinct. It thus continued until 1850–'51, when Baird put both in the same genus, and remarks concerning them: "The salamanders were formerly divided[1] into two great genera, Salamandra and Triton, the former with rounded tail and terrestrial habits, the latter with compressed tail and aquatic. The necessity of further division has, however, become apparent, and the old distinction into land and water salamanders is no longer tenable as parallel to any anatomical features. Thus, of the highly natural genus Notophthalmus (Diemyctylus) one species (*Diemyctylus viridescens*) is the most aquatic of all American forms, the other (*D. miniatus*) the most terrestrial; yet the

Common Names.—1. Of the adult aquatic form: Spotted salamander, aquatic salamander, many-spotted salamander, common triton, spotted triton, crimson-spotted triton, spotted newt, water newt, eastern water newt, common newt, spotted eft or evet. 2. Of the red form: Scarlet salamander, yellow-bellied salamander, symmetrical salamander, red lizard, little red lizard, rain lizard, red salamander, red newt, red eft or evet.

Distribution.—Representatives of the genus Diemyctylus are found in Europe, Asia, and North America. In North America are two well-marked species,—the *D. torosus* of the Pacific slope, and *D. viridescens*, the subject of this paper, throughout a large part of the eastern region. (Cope, '87, p. 202.)

[1] The numbers in parentheses refer to the bibliography at the end of the paper.

two are so much alike in shape as to render it a matter of some difficulty to distinguish them."

Five years later this close similarity of the red and aquatic forms so clearly enunciated by Baird lead Dr. Hallowell ('56) to express the opinion that "*Diemyctylus viridescens* and *D. miniatus* are probably the same, the orange color and roughness being appearances which, the female more especially, presents after a long sojourn on land. At least this may be inferred from the known habits of the European Tritons."

Again, three years later Cope ('59) says: "We include in the above synonyms (of *Diemyctylus viridescens*) those of the nominal species *D. miniatus*, which we think with Dr. Hallowell ('56) is a state of *D. viridescens*. We have caught specimens . . . of every shade of color between vermilion and brownish-green. The color or character of the skin seems to be dependent upon the amount of moisture in the situations in which they are found. Those from high and dry spots are redder and rougher than those from marshy situations. Thus it is probable that this species undergoes changes similar to those of the European Tritons."

During the next twenty years opinions pro and con were expressed by various systematists, but the final and satisfactory proof of the identity of *Diemyctylus viridescens* and *D. miniatus* was given by Dr. Howard Kelly ('78), who "brought home a number of *Diemyctylus miniatus* Raf., or little red lizard or red eft, and after keeping them in a dark box filled with saturated moss, they changed their color from a bright vermilion to the olive state characteristic of the *D. viridescens*." The change took place in the autumn, and without entering the water, although they willingly remained in and under the water when placed there. He says further: "The conclusion, then, is that instead of two well-marked species or a species and a variety, we have but a single species, *Diemyctylus miniatus*."

Sarah P. Monks ('80), in discussing the differences in opinion concerning these two forms, adds: "I have also observed this change several times,"—*i. e.*, the change from the red to the viridescent form. "I have kept them (the larvæ) till they became terrestrial, and had yellow spots along their olive-green sides; but

they would not eat, and died in about a week. I am very sorry not to have been able to keep any till they reached the red eft stage. Their dying so young makes a break in the chain of observed facts that prove the red eft to be a young form of the spotted salamander. I believe, but am not able to prove at present, that the young *Diemyctylus viridescens* attains its red garb the summer it is hatched, remains that color about a year, then gradually becomes duller as it attains full size."

In 1886 Col. Nicolas Pike ('86) verified the observation that the red ones transform into the viridescent form under certain circumstances, and seems inclined to the belief of Hallowell ('56) and Cope ('59) that changed conditions produce the change in coloration : "I have gradually come to the conclusion that the two are identical. Some years ago I captured quite a number of red ones in the Catskill Mountains, brought them home and kept them in a box with other salamanders where they could resort to water if they chose. For some days they remained hiding under wet moss and stones, but finally crept out at night and went into the water. . . . In about three months they lost their bright red, and in less than a year they were of the usual olive of the *viridescens*. Another fact, still more decidedly bearing on the case, is that some two-year-old *viridescens* taken from the ponds and put in earth and dead wet leaves in a tub in my garden, without water, in a month or so began to lose their green tint and assume a dingy brownish hue. . . . When the young leave the water the food changes to spiders, insects, earthworms, etc., so totally different from the prey of the ponds, and it is most probable that this is the first cause in the change of color in the little Diemyctylus."

In 1890 Gage and Norris ('90) kept a bright red Diemyctylus, found in the woods, over the winter in a box of leaves and rotten wood with other salamanders. It was of the usual red color in the spring; but when opportunity was offered, it entered the water, and within two weeks had assumed all the characteristics of the viridescent form.

Finally, in the "Batrachia of North America" Prof. Cope thus summarizes the state of knowledge, as it then existed, with refer-

ence to these two forms: "There are two forms of this subspecies, which have received the names of *viridescens* and *miniatus* respectively. These have been shown to be stages of one and the same animal; they are not distinguished otherwise than as seasonal forms, which may be by reason of the environment rendered permanent for a longer or shorter time" (p. 207).

As seen by the above quotations, Say apparently made but a single species of the red and viridescent forms; but some later authors even placed them in different genera. Their great similarity was, however, remarked upon by Storer and others. Finally, since the work of Baird in 1850 they have remained in the same genus, but have been by many considered as distinct species. A further study and more careful observation of living specimens, have, since 1850, indicated the probability, and finally showed the certainty, that the two forms were states of the same species ('56–'90). Furthermore, these observations not only showed that the red, terrestrial form changes to the viridescent, aquatic form, but, where the matter is discussed, it is assumed that the reverse may occur, the difference of coloration, roughness, etc., being dependent upon season, food, and environment (Hallowell, '56; Cope, '59, '87; Pike, '86).

While Say ('19) says the young is of a uniform orange color, the sentence immediately following that statement, "It is decidedly aquatic," leaves one in doubt concerning his actual knowledge concerning the two forms. There is one author, however (Monks, '80), who distinctly intimates, although unable to prove, that the red form is a stage in the development of the Diemyctylus. Both Say and Monks are silent concerning the possibility of a return of the viridescent to the red coloration.

In order to complete the chain in the life-history of the Diemyctylus, and to determine so far as possible its habits, structure, physiology, and transformations during the varying phases of aquatic and terrestrial existence, the writer has availed himself of every opportunity for investigating it during the last six years. The results of this study may, perhaps, best be given by commencing with the egg:

Fertilization and Ovulation.—It has been assumed by most observers that, in analogy with the European tritons, the eggs of Diemyctylus are internally fertilized (Baird, '51; Whitman, '85), It is said to be external by Col. Pike ('86), who supposed that the eggs were laid in masses. So far as I have been able to ascertain, no one has previously undertaken experiments to definitely settle this point. The mode of copulation, if it may be so called, is so different from that described for the European tritons in which internal fertilization has been demonstrated that from it alone one would not expect internal fertilization. The hind legs of the male are exceedingly strong, and have developed on the ends of the toes dark, horny masses, also horny ridges along the inner or opposed surfaces of the legs (Pl. XXIII., Fig. 9). These are mostly absent in the summer. As the animals slowly move about in the water, when the male comes sufficiently near a gravid female, there is a rapid movement of the body to get above her, then the two powerful legs come together like the jaws of a steel trap, grasping the female either just in front or just behind her front legs. The ventral side of the male is thus applied to the dorsal side of the female in the thoracic region, and consequently the cloacal openings are very widely separated. The male keeps his position for an hour or longer, and during part of this time, as Baird ('51) remarks, "jerks the female round in the water most unmercifully." The cloaca of the male is very widely open and pressed against the back of the female, and when not swimming around the tail is waved from side to side. The cloacal papillæ or villi are brought into view by the eversion of the cloaca. They remind one of the cloacal villi or of the gill filaments of a male Necturus. In case the female shakes the male off, as sometimes happens, the cloaca of the male may remain everted, and the tail is waved from side to side while resting on the bottom or on a branch of vegetation. This also occurs when he voluntarily leaves her for the purpose of depositing spermatophores (Zeller, '90; Jordan, '91).

As the egg-laying never takes place during the mating, the eggs must be fertilized after laying by the zoosperms diffused in the water, or the zoosperms must in some way get into the cloaca or

oviduct and fertilize the eggs before they are laid. To determine which of these alternatives was correct a clean jar, holding about two liters of water, was taken, and in the water was placed a pair of Diemyctylus. About half an hour after the mating had ceased the water was filtered through absorbent cotton. Adhering to the upper part of the filter were multitudes of zoosperms. This showed that the zoosperms were emitted into the water. Another clean jar was then taken and partly filled with water from the university water supply, and into it were placed some Anacharis and Ceratophyllum that had been in the laboratory all winter, and not in contact with Diemyctylus. The female was then carefully rinsed in several waters, and finally under the tap, to ensure the removal of zoosperms from the surface. She was then put into the clean jar with the water plants. It was believed that in this way external fertilization would be precluded, and that if eggs were laid and developed it would prove internal fertilization. Commencing the day after isolation, this female laid eight eggs in four days (from the 9th to the 13th of April).

In laying the eggs the female would select a place, usually a well-leaved part of the Anacharis or Ceratophyllum. This was then clasped by the hind legs, and held close to the cloacal prominence. The body showed several writhing or serpentine movements, the legs were pressed somewhat more closely together, and then the female would move away without looking around to see whether or not the egg was securely protected. When first laid the albumen is quite cloudy, but soon clears up; it is also very adhesive, so that when forced in between the leaves it sticks to them and holds them together. It usually took from five to ten minutes to lay an egg. Those observed were laid in the daytime.

In case no green vegetation is present, the eggs are laid on bare stems (Pl. XXIII., Fig. 1) or on stones. The eggs must be laid on stones in nature when no vegetation is present, as occurs in some parts of Cayuga Lake, where they were found mating.

After a few days all but two of the eggs showed signs of development, and embryos in various stages were secured and sec-

tioned. Some were allowed to go on till hatched. This occurred in thirty-three days after the eggs were laid.

After laying the eight eggs no more were laid for over a week. She was then placed with a male for two or three days, when mating again occurred. After mating, she was again isolated as before to see if the ovulation would recommence, and if the eggs would be fertile. Seven days after isolation she commenced to lay eggs, and continued to do so until six or seven were laid. These proved fertile, and several stages of development obtained. This experiment indicates that for a single mating about six eggs may be internally fertilized, about the number found in the two oviducts at one time. It indicates, further, that in nature more than one mating probably occurs (see below); and finally, almost certain proof is given that the eggs are not externally fertilized, as in the last experiment none were laid until seven days after isolation. Three other females were isolated as described above, and the eggs proved fertile.

From these experiments it appears almost certain that the ova are internally fertilized, and as to the way in which the zoosperms reach the eggs, as there is no approach to a true copulation, the explanation of Professor Baird ('51) must be the correct one: "The seminal matter becomes diffused in the water, and fecundates the ova while still in the lower part of the oviduct." Or more probably the spermatophores recently described by Zeller ('90) and Jordan ('91) in some way aid the entrance of the zoosperms more surely than would simple diffusion in the water.

The time of ovulation was found to begin the first week in April in specimens obtained from a spring-fed pond, and to continue in different specimens from this pond till after the first of May. In specimens from Cayuga Lake, June 13th, eggs were obtained until June 18th. Probably in specimens obtained later eggs might have been obtained also. It would appear from this that the ovulating season is much earlier in the inland ponds than in the lake.

Autumnal Mating.—If adult specimens are obtained from their natural habitat in the autumn, the males will be found to possess the dark horny toe-tips and the ridges on the thighs as shown in

Pl. XXIII., Fig. 9; and the tail-fin will be found as fully developed as in April. It has also the wavy appearance as if it were too long for the tail. If the two sexes are placed together a typical mating will occur, and the emission of spermatophores will occur exactly as described for the spring, or proper breeding season (Jordan, '91). Observing the act of emitting the spermatophore and its subsequent examination is greatly facilitated by using a clean glass jar containing very little vegetation. The spermatophore is anchored on the bottom of the glass jar, and has the general appearance of a drinking-goblet,—that is, the attached part is like the broad base of the goblet,—and this is continued into a narrow part, upon the summit of which the oblong sperm-mass or sperm-ball (about 2x4 mm.) is attached, thus occupying the position of the cup part of the goblet, to continue the comparison. At first the sperm-mass is detached from the spermatophore with some difficulty, but later much more easily. If it is transferred to a watch-glass or a slide and examined in water, using preferably dark-ground illumination, the sperm-mass will appear like a mass of white ringlets, there being hundreds of zoosperms in each ringlet. The motion of the zoosperm as a whole, and the active waving of the lateral membrane or frill, is very vigorous. It was found also that isolated males would emit spermatophores, thus making them comparable with the European Triton (Gaŝcoe, '80).

It is not easy to understand the purpose of this autumnal mating, as no eggs were ever found in the oviducts in the autumn, and it is not known that ovulution takes place at other times than in the spring, or breeding season proper. Judging from what has been found concerning European forms, where the eggs laid proved fertile although wintered in the aquarium, and not in contact with the male since its capture, also from the several broods of young from the *Salamanda atra* with but a single fertilization, it appears probable that the zoosperms are stored in some way by the female until the time of ovulation. (See Gascoe, '80; Fatio, '72; Jordan, '91; Czermak, '43; V. Siebold, '58; Zeller, '90.)

So far as I know, the presence of the horny toe-tips and thigh ridges and the prominent tail-fin have been uniformly described

as characteristic of the spring,—that is, the breeding season proper. So also the autumnal mating is, so far as I know, an entirely new observation. It was observed many times by myself, and at two different times independently by Mr. F. B. Maxwell, fellow in zoology and botany in Cornell University.

Habits of the Larvæ and Duration of the Larval Period.—The eggs of the Diemyctylus hatch in from twenty to thirty-five days, depending upon the temperature. From the first the coloration approaches that of the viridescent form; it has also the slim appearance and delicate outlines of the more mature ones. The gills are very prominent at a very early age, and project obliquely over the back. The larvæ are very timid and exceedingly active when they move. Frequently they remain for a considerable time in the clear water of the aquarium, with the beautiful red gills outspread and the body straight as an arrow. If disturbed in any way they dart into the vegetation like a flash. The body is narrow and the head pointed, thus forming a very marked contrast with the broad-headed Amblystoma larvæ. Indeed, they so strikingly resemble the adult viridescent form that it is not difficult to recognize them.

When several different kinds of larvæ are in the same aquarium, they differ from the adult aquatic form, however, in that the tail-fin extends almost to the head as a dorsal crest, something as in *Triton cristatus.*

The food appears to be entirely of an animal nature. Specimens from the ponds where the conditions are entirely normal contained minute Crustacea, larval insects and snails, and in some, aquatic worms were found. The larvæ in the aquarium were kept in food by an occasional addition of water and vegetation from their natural habitat. Early in August, while the gills are still prominent, the characteristic vermilion spots commence to appear, thus giving the larvæ a still more striking resemblance to the adult (Pl. XXIII., Fig. 3). Water is frequently taken into the mouth and passed through the gill openings for respiratory purposes, and the oral epithelium is stratified and non-ciliated, as in Necturus. The œsophagus is lined with ciliated epithelium, but none is present at any time in the stomach, thus further agreeing with

Necturus and differing from the larvæ or tadpoles of the bullfrog (*Rana catesbiana*) (Gage, '85, Gage, S. H. and S. P., '90).

During the last half of August the gills begin to be absorbed and also the tail fin, and the larva more frequently goes to the surface for air. Finally, during the last of August and the first of September, the gills and tail fin being nearly absorbed, the larva keeps its head out of the water an hour at a time, and finally crawls out of the water entirely.

The larvæ do not, apparently, all transform during the first summer, for specimens with gills have been taken from upland ponds in November. The size attained by the larvæ before transforming is quite various. Those observed by me were usually about the size shown in the plate (3 to 4 centimeters long); but they may become much larger. Indeed, they may remain in the branchiate condition till they are as long as some of the adult aquatic ones, and two or three times the length of some of the red ones found in nature. Large branchiate larvæ were obtained for me by Instructor Pierre A. Fish from a fresh-water pond at Wood's Holl, Mass. The tail-fin is small in these large larvæ, and there is no crest extending to the head as in the smaller larvæ. Other unusually large-gilled larvæ will be described by Prof. O. P. Hay in the forthcoming report on "The Batrachians and Reptiles of Indiana," soon to appear in the report of the Geological Survey of Indiana.

Terrestrial Life.—In order to keep the young newts alive and in health, a large glass dish was taken and a considerable amount of moist leaves and rotten wood put into it. This was an attempt to imitate nature as nearly as possible. The young newts did well, and gradually began to assume a reddish brown color on the back instead of the viridescent color (Pl. XXIII., Fig. 4). The belly became orange. In fact, it was passing through an almost exact reversal of the transformation of a red into a viridescent form. Late in September and during the first half of October the appearance was that of a rather dark "red newt.." Specimens of the same size found in nature at about the same date showed the transformation of the coloration even more strikingly, as it was of a lighter red over the whole body.

During the transformation from the gilled aquatic to the gill-less terrestrial state the gill slits grow up, and the stratified, non-ciliated, oral epithelium of the aquatic larva is changed for a ciliated epithelium. The vermilion spots have one or more black pigment blotches bordering them, but there is rarely, if ever, a complete black ring around them as in the larger specimens (Pl. XXIII., Fig. 5). The spots differ in size, shape, and somewhat in arrangement in different specimens; in some the number on the two sidesis different (Pl. XXIII., Figs. 4, 8). The general coloration of the body is almost always lighter on the ventral than on the dorsal portion, and differs greatly in different specimens. In some specimens it is a bright color in which the yellow is very prominent, in others the shade is more red, and in still others it is a dingy reddish brown. As shown in Fig. 7, the area of deeper dorsal red corresponds closely with the area that becomes viridescent in the adult form. As to the seat of the coloration, it is mostly due to the network of branched cells under the epidermis. The cells of the epidermis at the opening of the cutaneous glands—*i. e.*, at the summits of the papillæ or tubercles—sometimes become brownish, and in specimens that have not moulted for some time give a dingy look.

It is a curious fact that in these red forms and in the adult green ones the so-called fat-body is almost invariably of the color of the skin on the ventral portion of the body, and under the microscope shows reddish bodies almost exactly the color of the coloring matter in the chromatophores under the epidermis. The vermilion spots are produced by a deeper or redder coloration of the chromatophores. With the micro-spectroscope no distinctive absorption bands were found.

The food during the terrestrial life consisted of spiders, insects and insect larvæ, and earthworms. The larger red specimens in captivity take earthworms with great readiness. In nature the red ones live in situations, mostly at a considerable distance from water, and as well remarked by Baird ('51), is the most terrestrial of all the American salamanders. It is found under sticks and stones, and especially under rotten logs and in moist woods. It is

very rarely seen wandering around except after a rain, hence it is quite generally believed by non-naturalists to rain down.

Their movements are quite rapid, and very quickly disappear if placed where they can crawl into the grass or among leaves. They will overcome quite prominent obstacles, and in getting down from a considerable height they use the tail as a fifth hand, like a monkey, and can practically support themselves nearly their whole length. The aquatic form also frequently makes use of the tail as a kind of hand in making its way around in the submerged plants. Sometimes they give out a kind of shrill squeak or cry, but this is not very frequent. The adult aquatic ones occasionally emit a similar cry also.

Although I have been unable to keep them in confinement from the egg until their final transformation into the adult viridescent form, I have been able to obtain from a locality where they were especially abundant [1] such a complete series that it is believed that the terrestrial life continues until the autumn of the third or the spring of the fourth year after hatching,—that is, when they are two-and-a-half or three years old.

Transformation into the Adult.—As previously stated, this transformation may take place either in the autumn or the spring, and in either of these times the transformation may take place: (1) while still on dry land; (2) after entering the water.

1. As the red Diemyctylus attains maturity (judging from the generative organs) it gradually assumes a brownish tint, which merges slowly into a viridescent coloration of greater or less intensity in different specimens. This may occur in the autumn without entering the water, but if placed in the water it willingly remains (Kelly, '78). In two specimens under my own observation, kept in a jar containing moist rotten wood, leaves, etc., the change came about the middle ot September. One was of an especially brilliant red, but within two weeks

[1] The favorable place mentioned above is Worcester, Otsego Co., N. Y., along one of the headwaters of the Susquehanna River. The specimens were obtained for me by my nephew, Albert Gage. About 12 miles from Ithaca the red form is also exceedingly abundant in and near an upland forest. This forest is not far from marshy places which are sources of small tributaries to the Susquehanna River on the south and Cayuga Lake on the north.

it, as well as its less brilliant companion, had assumed the characteristic coloration of the viridescent form. These two specimens were fed earthworms occasionally and kept in the jar until the following July. There was not the slightest indication during this period of nearly a year of a return to the red coloration, and the epithelium of the mouth remained ciliated. In the middle of July they were placed where they could enter the water, which they did with great readiness, and remained under for a considerable time at first. The time under water increased in length until within two or three days the pharyngeal respiration under water was fully established; and if put with specimens from pond or lake they could not be distinguished either by appearance or behavior. Furthermore, viridescent specimens from the water have been kept in the air for several months, but there was never any indication of a return to the red garb of the immature form. It was found, as shown in the accompanying plate, that some specimens from the water inclined to a brownish green, hence it was found desirable to note carefully the appearance at the beginning of the experiments. These experiments and observations seem to the writer to entirely preclude the notion that the red form owes its coloration to either food, season, or situation; but that it is normal for a given stage of its growth and development. It is believed also that this change of the red to the viridescent form without entering the water accounts for the belief among some naturalists that the adult aquatic forms voluntarily leave the water and become terrestrial.

2. In the observations of Col. Pike ('86) the transformation from the red to the viridescent form took place after entering the water, and apparently took place in the summer or autumn, although he does not state distinctly. In the cases observed by me one specimen was kept over winter in wood humus, and in the spring given opportunity to enter the water. It did so in a short time, and within two weeks had completely transformed. Two other specimens were found in the woods in the early spring; they likewise entered the water after a few days and gradually changed their red for the iridescent coloration, and assumed an aquatic life with the accompanying pharyngeal respiration and

non-ciliated oral epithelium. Observations have not yet been sufficiently numerous or under sufficiently normal conditions to determine how soon after becoming viridescent and entering the water eggs are laid.

Adult.—By the adult is here meant the olive-green or viridescent form (Pl. XXIII., Figs. 8–11). The normal habitat of the adult Diemyctylus is the water. In Ithaca, N. Y., Cayuga Lake, permanent pools in marshes and permanent spring-fed ponds in the higher or upland are favorite homes. The streams running into the lake are liable to sudden freshets, and Diemyctylus is rarely found in them, at least not within a mile or two of the lake valley. Specimens have been taken from the spring-fed ponds at all times of year except the depth of winter. For catching Diemyctylus in situations where the vegetation is abundant the best method has been found to take a strong net with a long handle and make blind sweeps with it in the water. Frequently where there is no sign of animal life, Diemyctylus and other batrachians may be taken in considerable numbers in this way. According to Storer and Holbrook, they may be seen occasionally in winter, swimming with great vigor under ice an inch thick. It is believed from the preceding that after once assuming an aquatic life the adult never leaves the water except on the drying of the ponds or a special scarcity of food. It is further believed from the facts stated above that although the aquatic forms may be kept in moist places out of the water for months, they never revert to a red coloration, and also that the viridescent forms found on land are in the great majority of cases transformed red ones that have not yet entered the water.

The food consists of insect larvæ, like caddis worms, adult insects, various aquatic worms, earthworms, small Crustacea, bivalve, and univalve mollusks. In captivity they learn to take bits of meat from a stick, to catch flies thrown on the water, and to catch tadpoles. It is quite possible that they indulge in this last mark of affection to their relatives in nature also. When catching tadpoles or other living prey the process is something as follows: The Diemyctylus moves slowly within reach of the prey, and remains perfectly quiet until the prey moves, when it is

snapped up quick as a wink, and it is rare that a failure is made. A tadpole is also liable to be caught if it attempts to swim by the Diemyctylus. In taking earthworms on land there is an attitude of the body and curve of the neck strikingly like the restorations of some of the ancient saurians seen in works on paleontology.

Moulting.—Both the red and the viridescent forms shed the skin at various times throughout the year. There seems to be no regular time, as in June, mentioned by some authors. In the terrestrial form the exuvium is liable to be much torn, but frequently I have seen in Cayuga Lake perfect specimens floating in the water, and appearing, as one might imagine, like the ghosts of their former owners. I have never seen the cast skin rolled up and swallowed by the aquatic form; but the terrestrial ones pull the exuvium off the tail with the mouth and afterwards swallow it.

Respiration and Relations to Oral Epithelium.—In the beginning of larval life the respiration is wholly aquatic; then, as the lungs become developed, it gradually changes to a mixed or combined respiration,—*i. e.*, to a respiration partly aërial and partly aquatic. Later, when the larva leaves the water and becomes terrestrial, the respiration becomes wholly aërial. Upon transforming to the viridescent form, and reëntering the water, the respiration again becomes mixed.

If one observes a terrestrial Diemyctylus carefully the floor o the mouth and pharynx will be seen to sink and rise alternately, and many times per minute. The appearance in pharyngeal inspiration may be seen in Fig. 10; in expiration, in Figs. 7 and 11. The same pharyngeal movements may be seen in a frog or turtle On entering the water the Diemyctylus remains under for a considerable time, and during its submergence the same rhythmical pharyngeal movements occur, and water instead of air is alternately taken into the mouth and expelled, as in the soft-shelled turtles; and, as in the soft-shelled turtles, it is believed that it is for respiratory purposes (Gage, S. H. and S. P., '85). It is further believed, from chemical analyses, and from experiments made with the respiration of tadpoles and with Ganoid fishes, that whenever respiration is thus mixed or combined "the aërial part

is principally to furnish oxygen and the aquatic part to eliminate carbon dioxide" (Wilder, '77; Gage, S. H. and S. P., '85, '86, '88; Mark, '90).

It has been found in every one of a great many cases that whenever the respiration is wholly aërial, the entire mouth cavity is lined with ciliated epithelium which is directly continuous with the ciliated epithelium of the œsophagus. This is found not only in the red forms and the viridescent forms that had not yet entered the water, but when an aquatic form was kept in the air for ten days or two weeks the epithelium of the mouth was likewise found to be ciliated like that of the proper aërial forms. This was verified on several specimens and direct comparisons made with specimens from the same aquarium.

The branchiate larvæ and the adult aquatic forms have an oral epithelium of non-ciliated cells, as in Necturus and Cryptobranchus. It is astonishing to see how quickly a Diemyctylus with purely aërial respiration and ciliated oral epithelium will assume a partially aquatic or mixed respiration and the ciliated epithelium of the mouth become non-ciliated. The change has something of the character and certainty of a simple chemical reaction, and appears to show the direct relation of the mode of respiration to the character of the oral epithelium.[2]

[2] To determine whether or not the mouth has a lining of ciliated epithelium, the animal is pithed and the slit of the mouth is continued along the body beyond the stomach. The floor of the mouth is turned over and the œsophagus slit into the stomach. In this way the mucosa from the tip of the snout to and into the stomach is freely exposed. Then minute blood-clots—a method first devised by Mrs. Gage, so far as I know—are placed on the mucosa at various points. Care is taken that there shall be no drying of the membrane by keeping it well moistened with blood serum or spittle. In this way it is exceedingly easy to determine whether or not there is a complete lining of ciliated epithelium, for the ciliary currents quickly sweep the blood-clots toward and finally into the stomach. It is also an excellent method for discovering small ciliated areas. In addition to this, careful microscopic examinations were made of the epithelium from various parts of the mouth. This, of course, had to be the method employed in determining the character of the oral epithelium at the beginning of an experiment with living specimens. In the scrapings from the mouth of an aquatic Diemyctylus a few ciliated cells may be found under the microscope, but in such specimens there were no demonstrable ciliary currents. The source of the few cells is thought to be from the opening of the glottis or from the ciliated lining of the mouths of the buccal glands.

Conclusions.—So far as I have yet been able to learn from the opinions of others or my own observations, no explanation has offered itself for the bright color of the terrestrial, red form. The color renders it exceedingly conspicuous, and there is no counter-balancing compensation in sexual selection, for the red form is sexually immature. The olive-green or viridescent color of the adult does render it inconspicuous in green terrestrial or aquatic vegetation; they are sometimes found in large numbers in water nearly devoid of vegetation, however.

With reference to the change from the aquatic to the terrestrial life, and later the return to an aquatic life, there is perhaps a more satisfactory explanation or hint. Diemyctylus conforms in habits with the vast majority of batrachians in going to the water to lay its eggs. Still conforming to the habits of the group, the larvæ, on reaching a certain stage of development, absorb their gills, leave the water, and become air-breathers. It is not the purpose of this paper to attempt a discussion of the causes which led, in the course of evolution, to the assumption of an aërial for an aquatic existence by the Diemyctylus and many other Batrachia. It must be assumed that the reasons were sufficiently potent. Two will occur to every one conversant with the breeding places of the batrachians,—the danger of the drying of the water, and the limited amount of food.

With but few exceptions, the preparation for reproduction requires the terrestrial forms to again enter the water, and the life becomes for a greater or less time once more partially aquatic. A partial return to an aquatic mode of respiration, and the taking in of water by the pharyngeal movements described above, is by no means restricted to Diemyctylus, but it may be seen in such highly terrestrial forms as the little brown tree-toad (*Hyla pickeringii*) and the yellow-spotted salamander (*Amblystoma punctatum*). It appears as if the surroundings of larval life, and the necessity for respiration brought about by the prolonged stay under water required for fertilization and ovulation recalled by a kind of organic memory the mode by which respiration was accomplished in larval life.

In Diemyctylus this mixed respiration and the food supply apparently proved so satisfactory that the aquatic life again became fixed, and, acting through numberless generations, the tendency to revert to aquatic life became so great that maturing forms sometimes enter the water at least six months before the breeding season (Kelly, '78). It does not, however, revert so completely to an aquatic life that it cannot, in case of necessity, again become terrestrial for a considerable time.

This permanent reversion to a primitive mode of life by Diemyctylus does not stand alone among the Batrachia. It is paralleled and even exceeded by Siren, which after passing through the ordinary larval metamorphosis, has its gills so far absorbed as to be mere stubs. It then not only returns to the water, but actually reacquires its gills (Cope, '85). These two cases seem to point to the conclusion that in the course of evolution the dangers and hardships of the land became equal or greater than those of the water for these forms, and they, by readjusting themselves to an aquatic life, rendered the struggle for existence less severe. Certainly there is no reason, in the fundamental idea of evolution, why an animal may not revert to an earlier condition, provided it becomes as markedly to its advantage as was the original departure from that condition.

Summary.—1. The red and the viridescent forms of Diemyctylus belong to the same species, the red form being an immature condition.

2. The ova of Diemyctylus are internally fertilized, and are laid singly on a submerged leaf, or between submerged leaves, and partly concealed by folding the leaves closely together. If no leaves are available, the eggs are laid on stones or bare stems. The eggs hatch in about thirty days.

3. In from three to four months after hatching, vermilion spots appear, and are symmetrically arranged along the dorsal aspect next the head. The general appearance is then strikingly like that of the adult male in the breeding season, except that the tail crest, instead of ending opposite the pelvis, extends nearly or quite to the head, as in the crested Triton. Later, gills and tail-fin atrophy, and the respiration becomes more and more aërial.

4. After the gills are absorbed the animal leaves the water, and the color gradually changes from an olive-green to brownish-red, and finally, during the same season, assumes a bright yellowish-red, the vermilion spots remaining and becoming partly surrounded by black pigment.

5. As the terrestrial life is assumed the stratified, non-ciliated oral epithelium of the aquatic larva gradually changes to a ciliated epithelium continuous with that of the œsophagus.

6. In the autumn of the third or the spring of the fourth year after hatching (when two and one-half or three years old), the red changes for a viridescent coloration. This may occur with or without entering the water. If the water is entered the animal changes to an aquatic mode of life.

7. On reassuming an aquatic life the ciliated, oral epithelium becomes again stratified and non-ciliated, as in the aquatic larva, and as in Necturus and Cryptobranchus.

8. After becoming adult and transforming to the viridescent coloration, the Diemyctylus always remains of that general color, and never again becomes red, even when kept out of water a whole year, thus showing that the coloration is dependent neither on food, season, nor environment, but is normal for a given period of life only.

9. The adult viridescent forms are purely aquatic under favorable conditions, and after once entering the water do not leave it, although they are able to live for several months, and perhaps indefinitely in moist places, wholly out of water. Rhythmical pharyngeal respiration is very marked both in air and under water.

10. The character of the oral epithelium seems directly dependent on the mode of respiration, being stratified and non-ciliated with a purely aquatic or a mixed respiration, and ciliated with a purely aërial respiration.

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EXPLANATION OF PLATE. (FRONTISPIECE.)

Transformation of *Diemyctylus viridescens*. Drawn from photographs and colored from nature by Mrs. Gage. All are natural size, except Fig. 2 and the vermilion spot, Fig. 5.

FIG. 1.—Branch of Ceratophyllum with Diemyctylus eggs between the needle-like divisions of the leaves; also nearly bare stem of Anacharis with egg attached.

FIG. 2.—Diemyctylus egg, in the yolk-plug stage of development, attached to an Anacharis leaf. It was from an isolated female, and the parchment-like envelope is ovoid. Outlined with an Abbé camera lucida, and magnified about seven diameters.

FIG. 3.—Dorsal, ventral, and lateral views of a larval Diemyctylus in August and September. The gills are considerably atrophied, and the coloration and vermilion spots resemble the adult.

FIG. 4.—Dorsal and ventral view of a larval Diemyctylus the last of September and first of October, after it has become entirely terrestrial and was gradually assuming a bright red color.

FIG. 5.—Enlarged vermilion spot with complete black ring.

FIG. 6.—Ventral view of a red Diemyctylus taken in the spring, and either two or three years old. This light yellowish-red color is very common. The enlarged vermilion spot (Fig. 5) is to show that in animals of this size and in the adult the vermilion spots are usually entirely surrounded by a black pigment ring.

FIG. 7.—Lateral view of a red Diemyctylus, to show the difference in coloration of the dorsal and ventral portions of the body. By comparing with the viridescent forms it will be seen that the deeper coloration corresponds in situation in the two. The darker red shown in this figure is perhaps more common than the color in Fig. 6.

FIGS. 8, 9, and 10.—Views of an adult male Diemyctylus in October. It was in this specimen that pharyngeal respiration under water was first noticed, in 1886. The color varies considerably, some being darker and some lighter than here shown.

FIG. 8.—Dorsal view. The number of vermilion spots is seen to be few and to differ on the two sides. As shown by the different figures on this plate, the number of vermilion spots varies considerably.

FIG. 9.—Ventral view, showing the dark, horny thickenings on the tips of the toes, and the ridges (commonly six) on the inner or opposing surfaces of the legs. These horny developments mostly disappear during the summer, immediately after the breeding season, and reappear in the autumn.

FIG. 10.—Lateral view, showing the tail-crest or fin, extending on the dorsal side to about opposite the pelvis,—not to the head, as in the European Tritons. This fin is less markèd in the female (see Fig. 12), and partly disappears after the breeding season. The cloaca is partly everted, and shows some of the lining fringes or villi. The floor of the mouth and pharynx are depressed as when filled with water or air in pharyngeal respiration. Compare Fig. 11.

FIG. 11.—Lateral aspect of a gravid female. This coloration is frequent in adult forms found in water. The hind legs and the tail fin are smaller than in the male. The pharynx and floor of the mouth are raised as in expiration,—*i. e.*, when the air or water is entirely expelled.

EDITORIAL.

EDITORS, E. D. COPE AND J. S. KINGSLEY.

ENDOWMENTS for the support of original scientific research are becoming more frequent in this country. Mr. Thomas Hodgkin, of Long Island, has presented the Smithsonian Institution the sum of $200,000, a part of which is to be devoted to investigations on the characteristics of the earth's atmosphere. He "reserves the right" to add $100,000 to the original amount. The new Rockefeller University of Chicago is to have a large endowment from Mr. Rockefeller for original research. A bequest was made by the late William B. Ogden, of New York, for the purpose of endowing a school of scientific research. The sum, which is between three and five hundred thousand dollars, has been offered by the executors to the same Chicago University, and has been accepted by them. The Philadelphia Academy of Natural Sciences has been the recipient of several bequests within a few years whose aggregate is considerable.

These accessions of strength for scientific research are gratifying, and the manner in which the moneys are expended will be watched with solicitude. The administrators of money are frequently not acquainted with the actual needs of practical research, and their first impulse usually is to erect expensive buildings. The amount of money thus expended frequently cripples the working power of the institution. An undue proportion is sometimes spent on media of publication, of which already many exist in this and other countries. The real need of original research is the endowment of tenable positions for men. This proposition is self-evident, but it has been, nevertheless, too much neglected. But should this liberal course be adopted by such institutions, the question of the appointments to be made at once presents itself. Boards of trustees, being rarely occupied with scientific research, are not generally well informed as to the merits of investigators. It is sometimes difficult to obtain unbiased information even from investigators themselves, who are frequently more or less influ-

enced by personal considerations, rather than by absolute merit. One criterion may, however, be safely trusted as a guide in this difficult question. Let appointees always be selected on account of work actually done. In this way, and in this way only, can the actual merits of a candidate be ascertained. Moreover, let this work have been extended over several years, and not be measured by a graduating thesis or an essay or two. It is never safe to appoint men on the strength of what they are going to do. When rewards are conferred before services are rendered, the services are sometimes never performed. Especially should trustees be careful to distinguish between original investigators and the various kinds of middle men that are so useful in other capacities. Such are teachers, popular lecturers, and compilers of general or popular books; very valuable persons, but not the proper recipients of any part of moneys left for the endowment of original research.

From the same point of view the administration of the affairs of our academies of science, which are media of original research, becomes important. The custom, very general in this country, of electing to membership any person who is willing to pay the entrance fee, must necessarily have bad practical results, in the directions above referred to as incidental to a board of non-scientific trustees. Special scientific knowledge is required for the administration of museums, publications, etc., and these have too often fallen into the hands of totally incompetent persons. It is to be hoped that with the increase in the endowments of our academies of science the necessity of electing members for financial reasons will disappear, and that the membership will eventually be more appropriate to the objects for which such institutions are created.

—WE learn that the committee of entertainment of the Washington meeting of the American Association for the Advancement of Science had a surplus over expenses of about one thousand dollars. We have already referred (NATURALIST, 1891, p. 939) to some economical features of the management by this committee, and we are now presented with another illustration of

their thriftiness. In a circular recently issued the committee recommends that the surplus be presented to the Cosmos Club of Washington, for the purpose of endowing a library. We shall be surprised if the Cosmos Club adopts this suggestion, although the same gentlemen are members of both. As the money was subscribed for the American Association for the Advancement of Science, and as the surplus was obtained by requiring the members to pay their own expenses on the excursions, it would seem that the association is the proper recipient of the money. It would no doubt be very welcome for any one of several objects.

—The dates of issue of the numbers of the NATURALIST for 1891 are as follows: January, February 21st; February, April 2d; March, April 25th; April, May 23d; May, May 28th; June, June 27th; July, July 31st; August, September 11th; September, October 6th; October, October 23d; November, November 17th; December, December 22d.

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RECENT LITERATURE.

Flower and Lydekker's Mammals.[1]—In this work we have the result of the combined knowledge of two of the most competent specialists in the field of mammalogy of the present time; and as is to be expected, it is a book of the greatest utility to the student. It is based on the article written by Prof. Flower for the "Encyclopædia Britannica," and has been brought up to date, with the addition of references to the paleontology, by Dr. Lydekker. The former part of the subject is more fully treated than the latter, which is simply

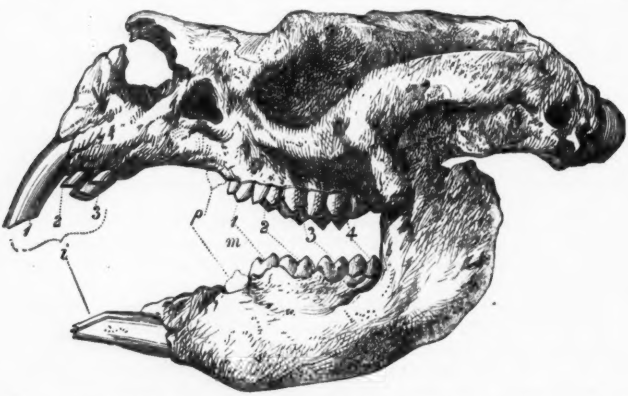

FIG. 1.—*Diprotodon australis* Owen. Extinct marsupial of Australia; one-tenth natural size. From Owen.

introduced to the reader. The illustrations number 357, and are of excellent quality. A majority of them represent the external appearance of the species; but many exhibit the osteology and dentition and a few, parts of the soft anatomy. The order of treatment is from the Monotremata to man, the unguiculate orders being intercalated between the ungulate forms and the Quadrumana. As the Quadrumana are more nearly related to the ungulate than the unguiculate orders, we would have reversed this arrangement. The orders which are treated with the greatest fullness of detail are the Marsupialia, the Diplarthra, and the Quadrumana. The systematic treatment inclines to conserva-

[1] An Introduction to the Study of Mammals, Living and Extinct. By William Henry Flower and Richard Lydekker. London: Adam & Charles, 1891, 8vo., pp. 763.

FIG. 2.—*Thylacoleo carnifex* Owen. Extinct carnivorous marsupial of Australia; skull, front view; one-third natural size.

tism, a quality which is of great value in restraining the tendency to excessive subdivision usual among tyros in zoology. In some cases, however, we incline to think it carried too far: as, for instance, when the African rhinoceroses are retained in the same genus with the Indian species; and where all ungulate Mammalia are included in a single order. A little more conservatism would have been consistently shown in the treatment of the Artiodactyla, where the two untenable families Giraffidæ and Antilocapridæ are admitted, and the long list of genera of antelopes is adopted. In the matter of the genera of antelopes, European authors have been apparently unconsciously influenced by the number of species at their disposal, rather than by an observance of the rules they have followed in other divisions.

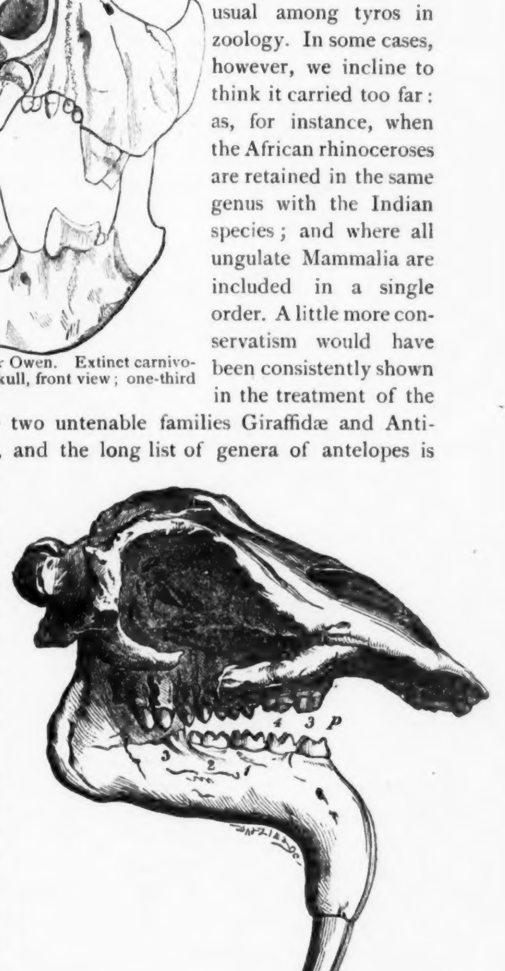

FIG. 3.—*Dinotherium giganteum* Kaup. Extinct proboscidian from Germany; one-tenth natural size. From Kaup.

A few points where the authors have fallen into error in the matter of American forms may be noticed for the benefit of future editions of the book. Tillodontia are placed under Ungulata, but they are distinctly unguiculate; so also are Chalicotheriidæ which are placed in the

Perissodactyla. The *Coryphodon elephantopus* Cope is figured as *C. hamatus* Marsh. If the figures of the latter given by Marsh are correct, it belongs to both a species and genus distinct from the former. The name of the creodont genus Oxyæna should not be spelled Oxhyæna, as the first syllable of the word hyæna does not enter into its composition. (Dr. Lydekker would also spell the saurian genus Platecarpus "Platycarpus," although its etymology was stated to be from πλατη, an oar, and not from πλατυς, flat.) The cameloid genus Eschatius includes only the species *E. conidens*, and not the *Holomeniscus vitakerianus*. These slight blemishes can be easily removed; and we will hope that a further consideration of the subject will lead to some modification of the systematic arrangement of the orders in a

FIG. 4.—*Dorcatherium aquaticum;* West Africa. From Flower and Lydekker.

future edition. Paleontological research has shown that the unguiculate and ungulate series are distinct from the phylogenetic standpoint, the former remaining tritubercular in molar dentition, while the latter became early quaditubercular and lophodont, and mainly continued so.

The natural character of the order Edentata has been demonstrated by paleontology, and it is treated accordingly in the work before us. An especially valuable section is that devoted to man, which constitutes the most valuable popular review of the subject of physical anthropology that we have.

This book is the only comprehensive one on the Mammalia in the English language, and we know of no better one in any language.—E. D. COPE.

Gems and Precious Stones of North America,[2] by G. F. Kunz, has for its object, to quote from the author's introduction, the presentation of "as many of the facts as possible regarding the precious stones peculiar to the United States, Canada, and Mexico, so that they may be available, not only to the mineralogist, the miner, the mineral and gem collector, the archeologist, and the jeweler, but also to the public; the conditions under which they occur, the methods by which the mining and search for them are conducted, the value and production of different stones, and also an account of the collections in these countries."

Although not pretending to be a complete treatise on gems, the volume certainly approaches nearer to this ideal than any other book published, either in this country or abroad. Not only are the true gem materials carefully described, but other substances more or less frequently used as ornamental stones are ably discussed. Eleven chapters deal with the properties of valuable stones, the history of their occurrence in North America, statements of authenticated finds, descriptions of the most noted gems in the possession of Americans, and many interesting facts concerning their present as well as their prehistoric use. A twelfth chapter treats of pearls in the same detailed manner. Chapters thirteenth and fourteenth give accounts of Canadian, Mexican, and Central American gem localities, and the fifteenth chapter portrays the aboriginal North American lapidarian at work. The sixteenth and last chapter is devoted to definitions to the value of importations of gem material, the methods of preparing it for sale, and to the descriptions of famous American collections.

If space permitted, an abstract of Mr. Kunz's book would be well worth giving; but since no abstract that would be at all worthy of presentation as representative of the great wealth of interesting material found in the volume could be made that would fall within the limits of a review article, it seems best not to insult the artistic tastes of gem connoisseurs by an attempt at a brief outline of this excellent treatise and piece of art,—for the volume is not merely a work on art; it is itself a piece of art. The colored plates of precious stones show these objects in all their beauty; more especially are the plates illustrating the garnets and the tourmalines to be mentioned. In the former we can actually see the sparkle of those magnificent blood-red gems as they lie in a brilliant beam of light, while a glance at the latter must make the heart of any true son of Maine beat fast at the thought of such beauty coming from the rugged hills of his mother state.

[2] A popular description of their occurrence, value, history, archeology, etc. New York: Scientific Pub. Co., 1890, p. 336, vi.; 8 lith. plates and numerous illustrations.

To the gem dealer the book is invaluable, as it gives him at once all that he needs in his business; to the lover of art it will afford many an hour of pleasure; to the gem collector it gives numerous points of interest concerning the rare stones; and to the mineralogist it will prove a veritable mine of information, even in those subjects with which he thinks himself already conversant. Nor will the general reader, if well informed, be disappointed in his perusal of its pages, for he will find everywhere items of news that will add to his stock of useful knowledge, and suggestions that will help to develop his appreciation of the beautiful.

The setting in which the "Gems and Precious Stones of North America" appears is well worthy of such lovely products of nature. The publishers have spared no efforts to enhance their beauty by an appropriate mounting. The plates and illustrations in the volume are excellent, the letter-press is marred by few errors, the paper is heavy, soft, and well tinted, and the binding is very tasty. We expect to hear of the books meeting a ready sale during the coming holiday season, for surely no more acceptable gift could be imagined than a handsome volume on a topic of such interest as the production of exquisite gems in prosaic North America.—W. S. B.

General Notes.

GEOLOGY AND PALEONTOLOGY.

The Age and Origin of the Crystalline Rocks of Missouri.[1]—The Geological Survey of Missouri is indebted to Mr. Haworth for a valuable paper on the age and origin of the crystalline rocks of that state. Mr. Haworth's study of these rocks began in the summer of 1886, and he has ever since pursued the subject with enthusiasm and zeal. His paper embodies the more important results obtained from a somewhat extended examination of the crystalline rocks in the vicinity of Pilot Knob. Field work has been supplemented with laboratory examination, and his conclusions are as follows:

I. As to age, he agrees with other geologists in referring them to Archean time.

[1]The Age and Origin of the Crystalline Rocks of Missouri. By Erasmus Haworth. Bull. No. 6, Geol. Surv. of Missouri.

II. As to origin, he is at variance with others who have worked in the same field, in that he holds the porphyries as well as the granites to be ancient eruptives rather than metamorphosed sediments.

The Archean age of these rocks had been fully established, but Mr. Haworth's observations gave him new evidence, confirming the accepted view, which he groups under two heads:

1. Absence of contact metamorphism in the surrounding Paleozoic rocks.

2. Inclusion of numerous fragments of crystalline rocks almost everywhere, in both sandstone and limestone.

In proof of his eruptive theory of the origin of the rocks, Mr. Haworth presents the following evidence in detail:

A. Field evidence of the eruptive origin. 1. Absence of true bedding. 2. Flow structure, banded structure, and lithophysæ. 3. Breccia. 4. Scoria and amygdaloids. 5. Tuff. 6. Absence of gradations of crystalline into non-crystalline rocks.

B. Petrographic evidence of the eruptive origin. 2. Texture of the ground-mass in the porphyries and breccias. 2. Flow structure in the porphyries and breccias. 3. Broken crystals due to the flowage of lava after the crystals were formed. 4. Magmatic corrosion of porphyritic crystals, and of fragments in the breccia. 5. Amygdaloids. 6. Absence of metamorphic minerals.

The paper is well illustrated with plates and sketch maps, which add materially to its value.

The Sulak Gorge.—In a paper on the Transverse valleys in the Eastern Caucasus, Professor Sjögren gives the following description of the Sulak Gorge, below Gimri, in Daghestan: "Among the many valleys of Daghestan that are interesting to the geologist, there are none more remarkable than the channel by which the river Sulak passes through the chain of Cretaceous and Jurassic mountains which borders Inner Daghestan. Just above the entrance to this defile the four rivers Koissu unite in one stream, which, in series of cataracts, tears through a tremendous chasm some fifteen miles in length, cutting the huge ridge almost at right angles to its axis.

"The gorge traverses the main ridge in the direction north, forty degrees east, then changes its line to northwest, which it still follows at the widening of the valley below Tjirkei, and finally comes back to due north, as it passes through the Tertiary hills below Subut. . . . The huge cutting has a vertical depth of from 5,000 to 6,000 feet, while its breadth is so small that the river leaves no room for a proper

road, and scarcely enough for a narrow horse-path, which is itself impassible at certain seasons of the year. The walls of the defile, which mainly consist of a compact dolomite limestone, and show the lines of stratification with unusual distinctness, rise almost perpendicularly into the air, and are altogether unscalable." (*Geol. Mag.*, Sept., 1891.)

An Olenellus Zone in the Northwestern Highlands of Scotland.—At the last meeting of the British Association for the Advancement of Science, Sir Archibald Geikie read an important paper on the results of the geological survey work in Scotland. After referring to the various sedimentary formations which overlie the Lewisian gneiss, and the unsatisfactory evidence of the fossil remains in them as to their stratigraphical correlation, he described the discovery of a peculiar zone of blue or black shales which from their unaltered character promised to be fossil-bearing. This zone lies in what is known as the "Fucoid beds" a few feet below the persistent band of "Serpulite grit." A search was at once begun, and resulted in the finding of undoubted fragments of Olenellus. More recently additional pieces of Olenellus, including a fine head-shield with eyes complete, have been found in another thin seam of black shale interleaved in the "Serpulite grit." The finding of this fossil among the rocks of the Northwest Highlands, and its association with the "Serpulite grit," afford valuable materials for comparison with the oldest Paleozoic rocks of other regions. The "Fucoid beds" and "Serpulite grit," which intervene between the quartzite below and the Durness limestone above, belong to the lowest part of the Cambrian system. The quartzites form the arenaceous base of that system, while the Durness may be Middle or Upper Cambrian. The marked unconformability which intervenes between the Torridon sandstone and the overlying quartzite points to a long interval having elapsed between the deposition of the two discordant formations. The Torridon sandstone must therefore be pre-Cambrian. (*Nature*, Sept. 17th, 1891.)

Origin of Petroleum.—In a recent paper Mr. Ross has endeavored to prove that petroleum is mainly generated by the action of solfataric volcanic energy upon beds of limestone, and gives equations to show that the action of sulphur dioxide and sulphuretted hydrogen on carbonate of lime, with or without water and peroxide of hydrogen, is capable of producing the ethylene and marsh gas derivatives. (*Nature*, Sept. 17th, 1891.)

A Stegocephalian Skull from the Kilkenny Coal Measures.—Dr. Lydekker has described and figured a Labyrinthodont to which he gives the name *Ichthyerpetum hibernicum*. The interest of the specimen lies in the relationships of the genus to which it belongs. Mr. Lydekker believes it to be a member of the group containing Brachyops, Bothriceps, and Micropholis, all of which are characterized by their more or less parabolic skulls and forwardly placed orbits. Also, certain lines of evidence point to the conclusion that Ichthyerpetum and Pholidogaster are identical. In that case, the type of Stegocephali common throughout the European Carboniferous was represented in the Lower Gondwanas by the genus Brachyops, while we find it surviving in the Hawkesbury beds of Australia, where it is represented by Bothriceps; a member of the latter genus, together with Micropholis, also occurring in the great Karoo system of South Africa. This seems to be another instance of the persistence of types in the Indian, Australian, and Ethiopian regions during long ages after their total disappearance from the palæarctic area. (*Quart. Journ. Geol. Soc.*, Vol. XLVII., Pt. 3, 1891.)

A New Ichthyosaurus.—Dr. Albert Gaudry calls attention to a gigantic Ichthyosaurus, which, after having figured in the exposition of 1889, has been generously donated to the Natural History Museum of Paris by MM. Millot, the owners of the quarries where it was discovered. This fossil was found in the chalk of the Upper Lias of Sainte-Colombe, near l'Isle-sur-Serein, about 12 kilometers from Vassy (Yonne). It is the largest Icthyosaurus ever found in France, measuring 8 metres in length. The head is 1m, 57 long; the anterior extremity is broken, but its length is judged to be about 1m, 80,—that is to say, 24 centimeters more than *Ichthyosaurus platyodon* of England; the eye, ornamented with sclerotic plates, has a diameter of cm. 24; the snout is very much prolonged, and there are about 24 teeth on one side, counting those of both upper and lower jaws; twenty-four vertebræ, altogether 4m, .40 in length, are preserved. The anterior and posterior limbs are joined to the skeleton, but many of their bones are lost, and the remaining ones are scattered.

After having compared this magnificent reptile of Burgogne with other known Ichthyosaurs, M. Gaudry considers it intermediate between the two principal groups, those of Longipinnes and Latipinnes, and proposes to name it, provisionally, *Ichthyosaurus burgundiæ*. (*Revue Scientifique*, Aug., 1891.)

The Skull and Hind Extremity of Pteranodon.—Early in the season of 1876 the writer collected from the Cretaceous of Kansas the first approximately complete skull known of an American Pterodactyl. Upon this specimen Professor Marsh, in the June number of the *American Journal of Science* for that year, founded the "order" Pteranodontia, expressly stating of the specimen that it might be "regarded as the type of the genus Pteranodon." Eight years later, in the May number of the same journal, he gave a fuller description of this same specimen, figuring it under the name *Pteranodon longiceps*.

The specimen consists of the skull alone, and was discovered partly exposed on a gently sloping surface, in the vicinity of Monument Rocks. Aside from an unfortunate stroke of the pick that chipped off the tip of the bill, the specimen was otherwise incomplete, in that the distal part of the occipital crest was lost. In his plate Professor Marsh restored this crest from the indications presented by the basal portion, but without indicating in his paper that such a conjectural restoration had been made. The result is unfortunate.

The writer the present season has been fortunate in securing for the University of Kansas a yet more complete skull of apparently the same species, discovered by his assistant, Mr. E. G. Case, in the immediate vicinity of the place where Professor Marsh's specimen was found. The specimen, while agreeing essentially with the type specimen, has a crest not more than half as long as that figured by Marsh, and with a very different outline, in that the posterior inferior border is angulated and concave. The crest is much thinner than is figured by the artist. The animal did not have nearly so remarkable a skull as the figures would indicate.

"There was apparently no ring of bony sclerotic plates, since in the best preserved specimens no traces of this has been found."[1] Nevertheless, well ossified sclerotic plates do exist in Pteranodon, as our specimen shows. They are from six to eight millimeters in diameter, and similar in texture and shape to, though without the imbrications of, those of the Mosasaurs (the so-called dermal scutes of Marsh).

Several unusually perfect specimens in the Museum of Kansas University enable me to give the chief characters of the pelvis and legs of Pteranodon, parts hitherto but little known,[3] and which will be supplemented, as also those of the skull, by figures given later.

In no especial respect do those parts present unusual features among

[1] Marsh, *Amer. Journ. Sci.*, XXVII., p. 425.

[3] See Marsh, *Amer. Journ. Sci.*, Dec., 1876.

the Pterodactyls. The ilium has a long anterior projection, with an expansion at or near the front end. Posteriorly it extends more stoutly upward and backward from the acetabulum, to form a close union with the three posterior sacral vertebræ, terminating in a stout, styliform tuberosity on either side of the base of the tail. The pubis and ischium are thoroughly coössified throughout (there may be a slit-like indication of an obturator foramen below), forming a broad, anteroposterior plate, which is narrowed to form a symphysis of about one inch in length, in the medium-sized species. Projecting downwards and forwards, about midway between the acetabulum and symphysis, there is a moderately thickened, angular projection, evidently tipped with cartilage in life. It corresponds to the pectineal process, and may have been for the attachment of pectineal or rectus muscles, or for the so-called prepupic bone, a bone I have never seen in the hundreds of specimens which I have examined. A little below the acetabulum, and a little before the middle of the conjoined plate, there is a moderate sized, oval, anteroposterior, pubic foramen. On the border of the ischium behind, a little above the symphysis, is another tuberosity, larger and stouter than the pubic one. Between this tuberosity and the iliac tuberosity directly above, there is a large, deep sciatic notch. These two tuberosities seem to indicate that the animal in life was in the habit of resting upon these parts, a supposition further helped by the weakness of the legs and by the structure of the femur. There are indications of seven sacral vertebræ in the specimen described. Marsh has given five as the number in one species. With the specimen were two apparantly basal caudal vertebræ of small size. The femur is a moderately stout bone, considerably shorter than the tibia, considerably curved, with a slender neck, set at only a slight angle with the shaft, nearly spherical head, and small trochanter,—all of which, together with the rather shallow imperforate acetabulum, would indicate great freedom of movement in the legs. The tibia is a slender bone, without marked cranial crest, and with a well-developed trochlear surface below. I know of no indications of a separate fibula. The foot is elongate and slender, the metatarsals articulating closely together above, the claws much smaller than those of the manus, and only slightly curved. There are three tarsal bones, two of them cuboid or angular, the third larger, and with a downward directed, pointed, hook-like process. It evidently indicates a rudimentary digit. There are four functional toes, the four elongate metatarsals in length indicated by the numbers 2, 1, 3, 4, of which the second is the largest. The phalanges may be represented by the formula I-2, II-3, III-4, IV-5;

thus, as in the European Pterodactyls, corroborating the evidence that the fifth toe is the one that is rudimentary. All these phalanges are slender, excepting the second ones in the third and fourth toes, where they are scarcely longer than wide.

From evidence obtained in the field and in the laboratory, I think I can safely say the following in general of the American Cretaceous Pterodactyls. About five or six species are known, varying in size, when alive, of from about four feet to not over twenty feet in expanse of wing.[4] The head (in all the larger species, at least) was elongate and slender, with a well-developed occipital crest, and without teeth. The jaws may have been encased in horn, but I have never seen any evidence whatever that such was the case. The neck was moderately elongate and slender; the thoracic girdle very stout and rigid, supported above, in some species at least, by union with the coössified thoracic vertebræ, below by the stout anterior projection of the large, rounded, thin sternum. The arms and wrists were very powerful; the second, third, and fourth fingers, as Marsh has shown, small and short, but terminating in strong, recurved claws; the fifth, or extraordinarily developed wing-finger, having very great freedom of backward movement at the extremity of the elongate metacarpal, and with only limited motion between the four phalanges. The body was short, the pelvis of moderate size, the hind legs comparatively small, with great freedom of movement, the tail short, and the feet without much, if any, prehensile power. Their food probably consisted of fishes.[5]

All the bones throughout the skeleton are very thin-walled and pneumatic. The haversian canals and lacunæ are small.—S. W. Williston.

Geological News.—General.—Mr. J. B. Tyrrell reports a deposit of mineral resin resembling amber along the ridge of a beach on the west shore of Cedar Lake, North Saskatchewan, Canada. It has evidently been washed up on shore by the waves, but its exact age has not been determined. (*Am. Journ. Sci.*, October, 1891.)

Archean.—Mr. J. W. Gregory is convinced that the Tudor specimen of Eozoon is not of organic but of mineral origin. (*Quart. Journ. Geol. Soc.*, August, 1891.)

[4] This expanse has often been given much greater than this, but I have actually measured the largest species (*P. umbrosus* Cope). and know that the size cannot exceed that given above.

[5] Several coprolites found within the above-described pelvis, ellisoidal in shape, and about the size of an almond, showed bones so finely comminuted that their precise character could not be made out.

Paleozoic.—Recent observations by S. Calvin render it certain that the Independence shales do not constitute the lowest number of the series of Devonian rocks of Buchanan county, Iowa, but that they were preceded by brecciated limestone of Devonian age. (*Am. Geol.*, September, 1891.)——Mr. Middlemiss suggests that the sub-Cambrian salt marl of India has no ordinary stratigraphic relations with the rest of the series, but is of plutonic, igneous, or deep-seated origin, introduced in Tertiary times, accompanied by lateral and vertical disturbance, thrusting, and shearing. (Geol. Surv. India Records, Vol. XXIV., Pt. I., 1890.)——Dr. Traquair has catalogued fifty species of fossil Dipnoi and Rhipidopterygia of Fife and the Lothians. The geological interest of these fish beds is the abundance of fish remains in estuarine strata below the horizon of the Millstone grit. (Proceeds. Roy. Soc. Edinburgh, Vol. XVII., p. 385.)——Mr. Davis has described a new fossil fish, *Strepsodus brockbankii*, found in the Limestone of the Upper Coal Measures near Manchester, England. (*Geol. Mag.*, October, 1891.)——A collection of Lower Helderberg fossils from Albany, N. Y., has yielded a new genus of Ostracoda, described by E. O. Ulrich under the name Beecherella. Seven species of this new genus are figured in the October number of the *American Geologist.*

Mesozoic.—Mr. Wilson calls attention to the color-markings on a species of Brachiopoda, *Waldheimia perforata*, from the Lower Lias of Gloucestershire, England. The color indications are in the form of clearly defined concentric bands of black and white, of varying breadth. These bands are bilaterally symmetrical, and correspond in the two valves. (*Geol. Mag.*, October, 1891.)

Cenozoic.—According to G. H. Stone, the following-named classes of deposit are represented in the asphalt fields of Western Colorado and Northeastern Utah: (1) Asphaltic sand-rock, (2) bituminous shales or marls, (3) bituminous limestones, (4) outflow or overflow asphalt. These are lacustrine deposits, and will therefore present conditions somewhat different from those of marine beds. (*Am. Journ. Sci.*, August, 1891.)——Mr. Gilbert attributes the small anticlinal disturbance of a cliff of Devonian shale in Western New York, near Lake Erie, to the post-Glacial rise of temperature and consequent expansion of the rocks. Like other small ridges of Devonian shale in Northwestern Ohio and of Trenton limestone in Northern New York, they are shown to have been formed after the departure of the last ice-sheet. (*Am. Geol.*, October, 1891.)

BOTANY.

The Trees and Shrubs of the Basin of the Red River of the North.—In a recent paper on the "Geographic Limits of Species of Plants in the Basin of the Red River of the North"[1] Mr. Warren Upham discusses a number of interesting problems in geographical botany. This basin lies between 45° and 52° north latitude, and 95° and 106° west longitude. At its lowest point at Lake Winnipeg its elevation above sea-level is 710 feet, and from this it rises to 2,700 feet in Northwestern Manitoba and Eastern Dakota. The temperature of this valley ranges from 90° Fahrenheit to —30°, or even —40°. The annual rainfall is from 20 to 30 inches.

The boundary between forest and prairie is traced as follows: Beginning near the junction of the north and south forks of the Saskatchewan River (about lat. 53° north, long. 105° west), and running southeasterly to Duck Mountain, the south end of Lake Manitoba and Lake Winnipeg, thence southerly from fifteen to fifty miles east of the Red River to Central Minnesota, where it bears eastward, passing out of the Red River basin. West of this line the region is chiefly grassland, while east of it the surface is almost wholly timbered. "Groves of a few acres, or sometimes a hundred acres or more, occur here and there upon the prairie region beside lakes, and a narrow line of timber usually borders the streams, as the Red River and its principal tributaries; but many lakes and creeks, and even portions of the course of large streams, have neither bush nor tree in sight, and occasionally none is visible in a view which ranges from five to ten miles in all directions."

Mr. Upham discusses the trees and shrubs of the region as follows: "Many species of trees, which together constitute a large part of the eastern forests, extend to the Red River basin, reaching there the western or northwestern boundary of their range. Among these are the basswood, sugar maple, river maple, and red maple, the three species of white, red, and black ash, the red or slippery elm, and the rock or cork elm, the butternut, the white, bur, and black oaks, ironwood (*Ostrya virginica* Willd.), the American hornbeam (*Carpinus caroliniana* Walt.), the yellow birch, the large-toothed poplar, white and red pine, arbor vitæ, and the red cedar or savin. A few species of far northern range find in this district their southern or south-

[1] Proc. Boston Society of Natural History, Vol. XXV., p. 140.

western limit,—namely, our two species of mountain ash, the balsam poplar, banksian or jack pine, the black and the white spruce, balsam fir, and tamarack.

"Some of the eastern shrubs, which make the undergrowth of our forests, also attain here their western limits; but a larger proportion ot these than of the forest trees continues west along the stream-courses to the Saskatchewan region, the upper Missouri, and the Black Hills. Among the shrubs that reach to the borders of the Red River basin, but not farther westward, or at least southwestward, are the black alder or winterberry, and the mountain holly, staghorn sumach, the hard-hack, the huckleberry, the dwarf blueberry, and the tall or swamp blueberry (*Vaccinium pennsylvanicum* Lam., and *V. corymbosum* L.), leatherwood (*Dirca palustris* L.), and sweet fern. Shrubs and woody climbers, that have their northern or northwestern boundary in this basin, include the prickly ash, staff-tree, or shrubby bitter-sweet, frost grape, Virginian creeper, and the four species of round-leaved, silky, panicled, and alternate-leaved cornel (*Cornus circinata* L'Her., *C. sericea* L., *C. candidissima* Marsh [*C. paniculata* L'Her.], and *C. alternifolia* L. f.). On the other hand, shrubs of the north which reach their southern or southwestern limits in the Red River basin, include the mountain maple, the few-flowered viburnum and witherod, several species of honeysuckle (*Lonicera ciliata* Muhl., *L. cærulea* L., *L. oblongifolia* Hook., *L. involucrata* Banks, *L. hirsuta* Eaton), the Canada blueberry, the cowberry, *Andromeda polifolia* L., *Kalmia glauca* Ait., Labrador tea (*Ledum latifolium* Ait.), the Canadian shepherdia, sweet gale, the dwarf birch, green or mountain alder, beaked hazel-nut, *Salix balsamifera* Barratt, and *S. myrtilloides* L., var *pedicellaris* Anders., black crowberry, creeping savin, and the American yew or ground hemlock.

"No tree of exclusively western range extends east to the Red River basin, and it has only a few western species of shrubs, of which the most noteworthy are the alder-leaved June-berry or service berry (in Manitoba commonly called 'saskatoon'), the silver-berry (*Elæagnus argentea* Pursh), and the buffalo-berry (*Shepherdia argentea* Nutt.). To these are also to be added the shrubby *Œnothera albicaulis* Nutt., which occurs chiefly as an immigrant weed, and the small-leaved false indigo (*Amorpha microphylla* Pursh), which abounds on moist portions of the prairie. The silver-berry (usually called 'wolf willow' in the Red River valley) is common or abundant from Clifford, North Dakota, and from Ada, Minnesota, northwood, forming patches ten to twenty rods long on the prairie, growing only about two feet high and

fruiting plentifully, but in thickets becoming five to ten feet high. Its silvery whitish foliage and fruit make this shrub a very conspicuous and characteristic element of the Red River flora.

"The single species of true sage-brush belonging to this basin (*Artemisia cana* Pursh) extends east in North Dakota to the Heart Mound, six miles northwest of Walhalla, or thirty-five miles west of the Red River at Pembina, and to a hill close west of the Cheyenne River about eight miles south of Valley City, growing in both places on outcrops of the Fort Pierre shale. It attains a height of one to three feet, and the tough wood of its base is one to one and a half inches in diameter. *Artemisia frigida* Willd., called 'pasture sage-brush' by Macoun, is abundant throughout a wide area westward, extending east locally to 'the ridge' east of Emerson, Manitoba, the Falls of St. Anthony, and Lake Pepin."

The Bearberry in Central Nebraska.—Another of the puzzles in the geographical botany of the plains has recently turned up in the discovery of the bearberry (*Arctostaphylos uva-ursi* Spreng.) in a cañon in Custer county, in the center of the state. When it is remembered that this station is midway between the Missouri River and the foothills of the Rocky Mountains, and that the plains extend for hundreds of miles in every direction, and further, that it is in what is known as the "sand-hill belt," it puzzles one to account for the presence of this unlooked-for shrub.

Bearberry occurs in the Black Hills and in the Rocky Mountains. Northeastward its nearest station is near Lake Pepin in Minnesota. It does not occur in Iowa. In Missouri it occurs in the southeastern part only. It is doubtfully admitted by B. B. Smyth to his list of Kansas plants.

The Nebraska station is in the basin of the Loup River, a stream whose numerous branches are wholly confined to the central part of the state, all having their sources in the numberless springs of the "sand-hills." How did the Nebraska bearberry find its way to this out-of-the-way spot?—CHARLES E. BESSEY.

ZOOLOGY.

Preservation of Color in Animals in a Collection.—M. Richard Thorna, of Dorpat, Russia, believes that he has discovered a liquid that will preserve the natural color of zoological specimens. After washing, the animal is to be preserved in the following solution :

Sulphate of soda	100 grams.
Chloride of sodium	100 "
Chlorate of potash	100 "
Nitrate of potash	10 "
Water	1 litre.

The specimen must remain in the liquid from eighteen to twenty-four hours, after which it is to be put in alchohol, which must be changed once or twice. Animals so treated will keep their color, the tints of which will be slightly deepened. (*Revue Scientifique*, 27 June, 1891.)

The Structure of Serpula.—Mr. A. L. Treadwell describes[1] some points in the structure of the New England *Serpula dianthus*. He first points out that Professor Verrill in his original description has confounded dorsal and ventral surfaces in this worm, and then proceeds to describe the general structure of hypodermis, nervous system, tubiparous glands, and sex products. The digestive, muscular, and circulatory apparatus, etc., are much like those in Spirographis, described by Claparède, and hence are omitted. Most noticeable is the nervous system, in which the œsophageal commissures are double, the upper commissure on each side being almost entirely composed of nerve-cells. The much convoluted tubiparous glands lie in the firs body segment, and extend backwards to about the middle of the second segment.

Metamerism in Hexapods.—As a result of studies on the embryology of the cockroach, Professor Aug. Lameere, has arrived at the following conclusions :[2] The order of succession of the mouth parts as given by Savigny is accepted. In the head four pairs of cœlomic cavities are recognized, plus a median unpaired cavity, corresponding to the labrum which the author would homologize with the cavity of the anterior directions of the Actinozoa. The antennulæ of the Crus-

[1] *Zool. Anz.*, XIV., 200, 1891.

[2] Bull. Soc. Micros., Belg., XVII, 1891.

tacea and the cheliceres of the Arachnids are homologous with the antennæ of the Hexapods. The editor of the NATURALIST has reasons for believing that as soon as we know anything about the embryology of the Thysanures, many points in Hexapod morphology and in the relationships of the various Arthropod groups will receive a flood of light.

Cottus beldingii, sp. nov.[3]—In October, 1889, Mr. L. Belding obtained three specimens of a species of Cottus in Lake Tahoe, California. During June, 1890, we obtained a much larger number at the same place. A series of these was sent to the British Museum. The rest are in the collections of the California Academy of Sciences, No. 504. Mr. Belding's specimens are also in the collections of the Academy, No. 702. We also obtained a number from Donner Lake, California, No. 505, California Academy of Sciences.

These specimens represent a variety or species distinct from the Alaskan *Cottus minutus*,[4] with which it is most closely related.

Head 2¾–4; depth 4–5; D. VI.–VIII. 15½–18; A. 11–13; V. I. 4.

Head rather short and broad, the profile convex, more steep from eye forward; eye large, orbit 4–5 in head; interorbital concave, 2 in orbit; mouth large; maxillary reaching at least to below the pupil, about 2 in the head. Preopercle with a simple, backward-directed spine, very slightly curved upwards. Teeth on jaws and vomer, none on palatines. Skin smooth. Pectorals reaching vent, or further in young; ventrals 1⅓–2 in head. Distance of anal from caudal 1⅓ in its distance from snout. Anus nearer insertion of caudal than to end of snout. Mottled with black and white. About six blackish crossbars on back; the first across head just behind eyes, next at origin of dorsal. First dorsal tinged with rust, the second less so. All the fins except the ventrals spotted with dark. The ground color varies greatly with the bottom over which these fishes live.

The other species found at Lake Tahoe were *Phoxinus montanus* Cope, *Agosia oscula* Girard, *Algansea obesa* Girard, *Coregonus williamsoni* Girard, *Catostomus tahoensis* Gill and Jordan; *Salmo mykiss henshawi* Gill and Jordan. Besides these we obtained *Algansea olivacea* Cope, from Donner Lake.—C. H. AND R. S. EIGENMANN.

[3] We have lately examined series of specimens belonging to the Academy of Sciences which makes it quite certain that *Cottus gulosus* Girard is identical with *Cottus asper* Richardson.

[4] Dr. Jordan tells us the name *Cottus minutus* is preoccupied, and not available for the Alaskan species.

A New Diodont.—The fishermen at San Pedro during the past summer took a species of Chilomycterus which is the first that has been recorded from the Pacific coast of America. On account of the unreasonable price asked for it I did not obtain it, but took the following notes, which may serve to identify another specimen:

CHILOMYCTERUS CALIFORNIENSIS, sp. nov.—One specimen, 9⅞ in., San Pedro, California, July, 1891. No tentacles anywhere. Spines of back all low, those of front especially so, increasing in size towards belly, where they become much larger than those of the back. No spine on middle of forehead. A spine at upper anterior angle of orbit; one above, somewhat behind its middle; one slightly behind and above its upper posterior angle; another halfway between the last and the upper angle of pectoral; and another before and a little above the upper margin of the pectoral. Blue above, white below. Forehead and bases of all the fins with small ($\frac{1}{18}$ in.) dark spots, fewer on anal. Back densely covered with short streaks or bars, which become larger spots on sides. A few round, dark spots (¼ in. in diameter) on belly. Spots below eye larger than those on forehead, similar in size to those of caudal peduncle.—C. H. EIGENMANN, *Bloomington, Ind., Oct. 8th, 1891.*

Temperature and the Number of Vertebræ in Fishes.—Dr. Jordan's recent paper[5] on this subject possesses considerable interest. He shows by a review of the known facts that in those groups of fishes which have representatives in the tropics and in colder waters as a rule those species which come from the warmer waters the number of vertebræ is less than in the colder water relatives, a law which was first brought out by Dr. Gill. Dr. Jordan has collated a large number of facts, all bearing on this subject. It may be suggested that the same influences which cause this diversity have possibly given rise to the change of shape in the same species of mollusc as brought out by Prof. E. S. Morse.

Note on Gyrinophilus maculicaudus Cope.—In the year 1889 Mr. A. W. Butler, of Brookville, Indiana, presented to Prof. E. D. Cope some specimens of a tailed batrachian that had been taken near the town named, in Southeastern Indiana. They had been collected, I believe, by Mr. E. W. Quick, and had been suspected by both Mr. Butler and Mr. Quick to be an undescribed species related to *Spelerpes longicaudus*, which they greatly resembled. Prof. Cope's practiced eye immediately perceived that they were not members of the

[5] Proc. U. S. Nat. Mus., XIV., p. 107, 1891.

species named, and the results of his examination of the specimens were published in the AMERICAN NATURALIST, Vol. XXIV., page 967. Prof. Cope named the species *Gyrinophilus maculicaudus*, assigning it to this genus because he found the premaxillaries distinct, instead of being anchylosed, as they are in Spelerpes. The species is otherwise distinguished from *Spelerpes longicaudus* by having a broader, flatter head; differently disposed vomerine teeth; by a ground color of vermilion; and by a different arrangement of the black spots. The limbs are also longer than those of *S. longicaudus*.

I have had opportunities to examine several specimens, both living and alcoholic, of this beautiful species. Some of these have come to me from Brookville through the kindness of Messrs. Butler and Quick. Two others had been taken in the vicinity of Bloomington, Indiana, by Prof. B. W. Evermann, of the State Normal School. After making a careful examination of the premaxillaries of several specimens of *maculicaudus* and comparing them with those of *longicaudus*, I am compelled to differ from Prof. Cope as to the generic position of this animal. In the case of all the specimens that I have dissected, except one, I find the premaxillaries to be consolidated. I have taken the premaxillaries out, dried them, and examined them with a sufficiently high power of the compound microscope, without perceiving any evidences of a suture between them. I can see but slight differences between the premaxillaries of it and *S. longicaudus*. In Gyrinophilus the premaxillaries are easily separated. In the case of the exceptional specimen mentioned above, the premaxillaries had been broken by accident just a little to one side of the middle line. Had the fracture been exactly in the middle line, I should have concluded that in this specimen the two bones had not united. This suggests that possibly an accident had happened to the specimen examined by Prof. Cope. If, however, Prof. Cope's specimen really had the premaxillaries distinct, while in mine they are anchylosed, the genus Gyrinophilus cannot stand. In any case, the species will, according to my view, have to bear the name *Spelerpes maculicaudus*.

This animal is regarded by those who have observed it in its native haunts to be more aquatic in its habits than is *S. longicaudus*. The ones that I kept for some time in a small aquarium showed a disposition to remain out of the water. They would often climb up on the perpendicular glass wall of the aquarium above the water, and rest there for a long time. If, when thus adhering to the glass, this was turned in a horizontal position, they would continue to stick to the under side

of it. I was not successful in my endeavors to get them to eat while in confinement. They appear to endure imprisonment well.

During the summer of the present year my son, W. P. Hay, secured two additional specimens of this cave salamander in the region about Bloomington. One of these was taken in May's Cave, about five miles south of Bloomington and a mile west of Clear Creek Station. It was found sticking to the wall of the cave, about four feet above the water and about one hundred yards from the cave's mouth. The other was captured in Kern's Cave, one mile southwest of Bedford, in Lawrence county. This locality is twenty miles south of May's Cave, and both are about a hundred miles west of Brookville, the original place of the discovery of the species. This shows that the animal is pretty well distributed throughout the southern portion of Indiana, and will probably occur also in the caverns of Kentucky. The specimen taken in Kern's Cave was also found clinging to the wall above the water, and at a distance of about a quarter of a mile from the entrance. Neither of the specimens made any effort to escape capture. Attention was attracted to both by the gleaming of their eyes in the candle-light. —O. P. Hay.

Color Patterns in Cnemidophorus.—At the last meeting of the American Association for the Advancement of Science I read a paper on the color variations in two species of the above-named genus of lizards, the *C. gularis* B. & G. and *C. tessellatus* Say. In the young of both species the color consists of longitudinal stripes, six in the former and four in the latter, which has a lateral series of spots in place of the external stripes. This coloration is permanent in some of the *C. gularis* and in the *C. t. gracilis*. In both species can be traced an identical series of color varieties, which have especial geographical ranges, and which have mostly received names as speçies. The first modification is seen in the appearance of pale spots in the interval between the stripes, a character which partly defines the *C. gularis* B. & G. These spots are greatly enlarged in the *C. gularis scalaris* Cope, joining the stripes and breaking up the ground color into spots. On the other hand, the stripes may also be broken up into spots, producing a light-spotted form, the *C. g. communis* Cope. Returning to *C. g scalaris*, the dark spots may be confluent transversely. forming a transversely banded form. This transverse banding commences at the posterior extremity of the body. When it is restricted to this region and the anterior color pattern disappears, we have the

C. g. costatus Cope. When the color pattern consists of rows of oblong black spots on a dark ground the form *C. g. semifasciatus* Cope is produced.

We have the following results: 1. A longitudinally striped pattern passes into a transversely banded form, etc. 2. This series of changes is common to both species, *C. gularis* and *C. tessellatus*. 3. This series and some of the other variations are found in the *Lacerta muralis* of Southern Europe, as described by Eimer. 4. This kind of variation is not promiscuous or multifarious, but in series.—E. D. COPE.

A Rorqual on the New Jersey Coast.—A young specimen of Balænoptera came ashore at Ocean City, Cape May county, N. J., recently, and was secured for the Academy of Natural Sciences of Philadelphia by the efforts of Prof. A. Heilprin, Dr. S. G. Dixon, and Mr. J. I. Ives. It had been dead for a considerable time, and had lost its whalebone. Its long maceration rendered it possible to procure the skeleton in very good condition. It measured in the flesh 66 feet 11 inches in length; head to angle of mouth on curve, 16 feet 10 inches. The entire surface was of a purplish slate color, mottled with large blotches of a lighter tint; under surface of flippers, white. The characters of the skeleton are those of the *B. musculus*, with certain important exceptions, in which it resembles the *B. sibbaldii*. These are the enclosure of the vertebrarterial canal in the axis vertebra only; the large size, and the color. A full description of it will be published in the Proceedings of the Philadelphia Academy.—E. D. COPE.

New Mammals.—In *North American Fauna*, No. 5, Dr. C. Hart Merriam describes the vertebrate fauna of Southern Idaho. First is a general review of the region and its faunal provinces, and then follow annotated lists of species. Of mammals sixty-seven species are recognized, the following being new: *Sorex idahoënsis*, *S. dobsoni*, *S. vagrans similis*, *Onchomys leucogaster brevicaudus*, *Hesperomys crinitus*, *Arvicola macropus*, *A. mordax*, *A. nanus*, *Phenacomys orophilus*, *Evotomys idahoënsis*, *Thomomys clusius fuscus*, *Lepus idahoënsis*. The only new bird found was *Megascops flammeolus idahoënsis*, which is given a colored plate. The reptiles and Batrachia are catalogued by Dr. L. Stejneger, but embrace no novelties. In the same number Dr. Merriam also describes *Microdipodopus* [n. g.] *megacephalus* from Nevada, and *Evotomys gapperi brevicaudus* from the Black Hills.

Zoological News.—M. Aug. Lameere, professor in the University of Brussells, has published [6] a very readable paper on the "Origin of the Vertebrates." He defends and amplifies Sedgwick's well-known hypothesis, and like him derives the vertebrates, and by implication metamerism, from the Actinozoa.

C. Dwight Marsh publishes [7] a list of the deeper water Crustacea in Green Lake, Wis. He enumerates fourteen species, of which a Bosmina is new and *Diaptomus minutus* was before known only from Newfoundland.

EMBRYOLOGY.[1]

A New Larval Form from Jamaica.—The Marine Laboratory of the Johns Hopkins University was situated during the summer of 1891 on the Island of Jamaica, at a point on Kingston Harbor called Port Henderson. While a member of the party I obtained the larva described below. On the morning of June 24th, while examining the tow-stuff from the surface net, Mr. Charles Taylor, of Kingston, discovered the larva. He made a careful sketch of it from the living animal, and it is from this largely that the accompanying figure was subsequently made. The larva was turned over to me, but unfortunately on account of its minute size it was lost during the hardening process, so that all opportunity of a later and fuller examination is gone. Nevertheless, as I am quite sure the figure is accurate as far as it goes, and as the chance of finding another larva is not very good, I have decided to figure it, with a brief account of its capture.

Although there is no record as to the time in the morning when the tow was made, yet in all probability it was between the hours of six and nine A.M. About six or seven o'clock the land breeze that had been blowing during the night ceased, and there was generally a calm interval of an hour or two before the sea breeze (the trade) forced it way

[6] Bulletin Société Belge de Microscopie, XVII., 1891.

[7] *Zool. Anzeiger*, XIV., 275, 1891.

[1] Edited by Dr. T. H. Morgan, Bryn Mawr College, Bryn Mawr, Pa.

inland again. During these calm hours in the morning all the more important collecting was done.

The larva is undoubtedly a free-swimming stage of one of the marine Trematodes. Such pelagic larvæ—Cercaria—are not unknown, but have been now and then recorded by naturalists. The adult worms generally live, I believe, in marine molluscs, and the Cercaria is a larval form seeking a new host. The larva belougs to that division of marine larval Cercaria having bifid tails. Villot says that these Cercaria having split tails form a small very natural group, and are mostly found parisitic in fresh-water Mollusca; but a few are marine. One of these has been recorded by J. Müller as having been found near Nice, and has been figured in the inaugural thesis of Lavalette Saint-George, under the name of *Cercaria dichotoma*. I have not seen this figure, but judging from the account of the same larva given later by Claparede it is entirely different from the Jamaica larva.

TREMATODE LARVA.

Claparede, in 1863, figured a bifid-tailed Cercaria found in the sea. This is also quite different from the Jamaica Cercaria. The larva figured by Claparede is called *Bucephalus haimeanus*, and is very close, the author says, to *B. polymorphus*, described by Von Baer, and is the same as that described by Lacaze Duthier which lives in the mollusc Cardium. Both of these larva then figured by Von Baer and Lacaze Duthier must be different from the present form.

McCrady, in 1873, described a bifid-tailed Cercaria—*Bucephalus cuculus*—living in the American oyster. His figures show at once that the form he described is very different from the Cercaria from Jamaica.

Other descriptions than these I do not know of, and feel reasonably assured that the larva has not been figured before.

The Jamaica larva was a small, jelly-like, transparent body, being, at a guess, about a half a millimeter in length. It moved about quite actively by means of its tail. The latter structure is situated in a groove

on one side of the body, as shown in the figure. At about its middle the tail splits into lamella-like paddles, and it is this divided tail that forms the most interesting feature of the larva. On each side of the anterior end of the larva is a mass of dark granular mass. The other bodies found in the interior of the larva are shown in the accompanying figure.

We never succeeded in getting more of these Cercaria, although I looked for them on several occasions.—T. H. Morgan.

Hatschek's Interpretation of the Annelid Trochophore.—Zoologists and embryologists have looked forward with a good deal of interest to the publication of the third part of Dr. Berthold Hatschek's "Lehrbuch der Zoologie," in which he gives what may be considered the most recent and certainly the most novel treatment of that very heterogeneous group, Vermes (Zygoneura Hatschek).

More especially interesting is the treatment of the larval form of the Annelids,—the Trochophore. This is ground that Hatschek has himself covered very thoroughly, and his words must carry a great deal of weight along with them, whether his particular view be accepted or not.

"The Trochophore is the characteristic larval form of the Zygoneura. In structure, the Rotifers stand very near to the Trochophore, and the Turbellarians which only reach the stage of the Protrochula are very closely related to this last form. In many cases the characteristics of the Trochophore are more or less modified, or even entirely suppressed, as happens in direct development. The primitive type of the Trochophore may be determined by a comparison of those structures that are repeated in very widely separated groups of animals. A complete union of all the typical properties in a single larval form is perhaps never reached, still many Annelid larvæ approach very near to this." A very clear and full description is given of a typical Trochophore. This is illustrated by four new diagrams, that show the structure of the larvæ most excellently.

With respect to the phylogenetic interpretation of the Trochophore the author says: "If we assume as true that the Trochophora is the characteristic form of the Scolecida, Articulata, Tentaculata, and Mollusca, we have recognized a common body for all these groups. We may also assume a common descent, and state the law that the Zygoneura are derived from a common ancestral form, that has the Trochophora as a stage in the development. Further, we may ask the question whether the Trochophore is itself the repetition of an

ancestral form, and conclude that it is in the highest degree probable, inasmuch as we know several forms of animals which in their mature condition come very near to the Trochophore. Particularly is this true for the Rotifers. The little spherical Rotifer discovered by Semper in the Philippine Islands illustrates most fully this law ; and it is to be marked that this is a typical Rotifer, and that at the same time many other Rotifers in spite of their changed outer form possess many true Trochophore characters. On the other hand, it has been affirmed that the Rotifers are sexually mature larvæ of higher forms, and this is not entirely impossible, but it must be remembered that there is no definite evidence for this hypothesis. It is further to be noted that the Turbellarians in their adult condition approach very near to the Protrochula, except that in the adult form ciliated bands are wanting. The view that the inner organization of the Protrochula and Trochophora repeat ancestral characters is made probable by the very similar relations of the organs of the Platodes to the Rotifers. But even the outer arrangement of cilia of the Trochophore may in all probability be considered as an ancestral character, since it is found to some extent not only in the Rotifers but in other groups as well,—viz., in the Entoprocta and the Tentaculata as definite structures in the adult organization.

"We may thus formulate the following law: The Protrochula is a repetition of the Protrochozoon,—*i.e.*, the common ancestral form of all Zygoneura. The Trochophora is the repetition of the Trochozoon, —*i.e.*, the common ancestor of all the Zygoneura standing above the Platodes. The organization of the Scolecida is referred directly back to the organs of the Protrochula and Trochophora. This applies to the nervous system, digestive tract, muscles, and the proto-nephridia, but not to the gonads, which appear primitively paired in the Scolecida, and have the structure of sac-gonads with peculiar excretory tubes. Concerning the development of these there are few observations, but it is probable that the sac-gonads and the gonad ducts (viz., egg-tubes and sperm-tubes) are of mesodermal origin, and represent cœlomatous formations.

"Kleinenberg has attempted to derive the Trochophore from the *Medusa form*, comparing the preoral ring-nerve of the Annelid larva with the ring-nerve of the Hydromedusæ. This hypothesis is scarcely in accord with the rest of the organization. There is much better grounds for the belief that the Ctenophores stand very near to the Zygoneura. The sense-organ plate at the apical pole, the mesenchymatous musculature and the ectodermal œsophagus appear to be

related structures, also the ciliated apparatus of the Ctenophore may be compared with the preoral ciliated band of the Trochophora. We would assume that the cœlom sacs and nephridial canals of the Zygoneura (sac-gonads of the Scolecida) are derived from the gastric canals of the Ctenophores, and therefore that the mid-gut of all Zygoneura may be compared morphologically only with the central stomach of the Cœlenterates in general and the Ctenophores in particular, and not with the whole primitive digestive system of cœlenteric apparatus, as Lang has done."

ENTOMOLOGY.[1]

"Biological Papers."—With this general title Prof. Charles Robertson, of Carlinville, Illinois, has recently distributed, under one cover, a series of admirable papers on flowers and insects, and descriptions of North America Hymenoptera. In his studies of the former subject the author has followed closely along the lines laid down by Müller in his "Fertilization of Flowers," describing the structural peculiarities of the blossom of each plant considered, and the relative time of development of each part, and cataloguing both the species of insect visitors and the object of their visit. The length of these catalogues indicates an amount of careful field work which will be best appreciated by those who have tried it.

Lepidoptera of Buffalo.—The last number of the Bulletin of the Buffalo Society of Natural History contains an excellent "List of Macro-Lepidoptera of Buffalo and Vicinity" by Edward P. Van Duzee. In its preparation the author has been assisted by Dr. D. S. Kellicott, Mr. A. H. Kilman, Mr. Philip Fisher, and other members of the society. The list includes the Geometridæ and Pyralidæ, but omits the Tortricidæ and Tineidæ. The total number of species is 777, of which 361 are Noctuidæ. The same issue of the Bulletin contains an account of "Mill's Collection of Fresh-Water Sponges," by Dr. Kellicott.

Kerosene Emulsion.—In Bulletin No. 16 of the Michigan Experiment Station Prof. A. J. Cook discusses "Kerosene Emulsion and Its Uses." The article is evidently the result of a large amount of careful experimentation of the highest practical value, in which the

[1] Edited by Prof. C. M. Weed, Hanover, N. H.

author has been assisted by Mr. G. C. Davis. Prof. Cook describes under separate headings three formulæ for preparing the emulsion : the first is his own method of making an emulsion of soft soap and kerosene ; the second, his method of making an emulsion of hard soap and kerosene ; and the third is the well-known Riley-Hubbard formula. For success with the latter the experiments here reported indicate that soft water must be used. Th authors believe the pyrethro-kerosene to be a valuable insecticide, and report experiments in which kerosene emulsion has been successfully used against vermin on domestic animals, rose chafers, hollyhock bugs (*Orthotylus delicatus* Uhle.), yellow-lined currant bugs (*Pœcilocapsus lineatus* Fab.), immature squash bugs, aphides, pear slugs, and pea weevils. The Bulletin is illustrated by eight original figures, and altogether is one of the most useful and interesting of recent station publications.

Host-Plants of Aphididæ.—Mr. T. A. Williams has lately published as Bulletin No. 1 from the Department of Entomology of the University of Nebraska a "Host-Plant Index of North American Aphididæ." There is a short introductory discussion of plant lice by Prof. Lawrence Bruner, after which follows a list of North American plants and the species of Aphides which attack them.

Prof. Smith on the Rose-Chafer.—Bulletin No. 82 of the New Jersey Experiment Station consists of an extended discussion of the rose-chafer or "rosebug" (*Macrodactylus subspinosus*) by Prof. J. B. Smith, who states that "this insect has done more injury during the few years last past than any one other species in the state of New Jersey, excepting, perhaps, the codling moth and plum curculio." The author gives under successive headings an account of its history in New Jersey, food habits, mouth parts, habits of the beetle and larva, breeding grounds, life history, and remedies. Under the latter heading he reports experiments showing that for practical purposes in a region where the insect is so abundant the following substances have little or no remedial value : the arsenites, copper mixtures, pyrethrum, kerosene, lime, tobacco, acetic acid, quassia, digitalis, corrosive sublimate, muriate of ammonia, cyanide of potassium, "odorless insecticide," sludgite, kainit, alum, and hot water. The latter substance, which has lately been recommended by the *Rural New Yorker* as a rosebug remedy, was found to kill the beetles at a temperature of 125°, but the difficulty of applying it successfully was so great, on account of the cooling caused by evaporation, that it proved a failure

in the field. Professor Smith has found mechanical devices for collecting the bettles the best way of fighting them, and expresses the belief that they can be successfully subdued in this way.

Heteroptera of Tennessee.—Professor Summers[2] has gotten together a very useful synopsis of the Heteroptera of Tennessee. It follows the general lines laid down in Comstock's discussion of this group in his "Introduction to Entomology" (a discussion, however, in which Professor Summers's aid is frequently acknowledged by the latter author), and is illustrated by 14 figures and one plate. Two pages are devoted to a general discussion of remedies.

Entomological Personals.—During the last few months a number of American entomologists have changed locations. Dr. J. C. Neal, of the Florida station, has resigned to take the directorship of the new Oklahoma Station at Stillwater. Mr. C. W. Woodworth has gone from Arkansas to California, where he is located at the experiment station at Berkeley. Mr. F. J. Niswander, assistant to Professor Cook at the Michigan Agricultural College, has gone to the University of Wyoming at Laramie. Mr. C. P. Gillette, of the Iowa station, has accepted the professorship of zoology and entomology at the Colorado Agricultural College, and Prof. Herbert Osborn has taken charge of the Iowa station work. Mr. A. B. Cordley has left the University of Vermont to become an assistant of the U. S. Division of Entomology. An appointment of peculiar fitness is that of Mr. Frank Benton to the apiarian work of the same division. Mr. Benton is a graduate of the Michigan Agricultural College, and has spent the last ten years in Cyprus and other eastern countries studying and experimenting with bees. Dr. Riley has also arranged for other apicultural work by appointing Professor A. J. Cook and Mr. W. R. Larrabee field agents of the division. Mr. C. H. Tyler Townsend has left Washington to accept a chair at the New Mexico Agricultural College. Mr. F. M. Webster has gone from Indiana to the Ohio station at Columbus, where he is consulting entomologist, taking the place vacated by the editor of this department when he went to the New Hampshire State College. A foreign change that is worthy of notice is that of Professor T. Thorell, the veteran arachnologist, from Sori, Italy, to Montpelier, France.

Outlines of Entomology.—Miss Murtfeldt is to be congratulated on the admirable way in which she has gotten together an intro-

[2] The True Bugs, or Heteroptera, of Tennessee. By H. E. Summers, Consulting Entomologist. Bull. Tenn. Exp. Station, Vol. IV., No. 3, July, 1891, pp. 31.

ductory discussion of insect classification.[3] She has divided her work into thirty-one chapters, the first five of which deal with the external structures of insects and their transformations. Then the orders and suborders are taken up in regular sequence, and their characters clearly and concisely defined. We are glad to learn that the author intends to have these "Outlines" published in book form for school purposes.

Recent Bulletins.—Mr. F. M. Webster begins his work at the Ohio station by a timely discussion of the Wheat Midge, *Diplosis tritici* (Bulletin, Vol. IV., No. 5, September, 1891). This pest has appeared in Central Ohio in considerable numbers.——Professor F. J. Niswander discusses plant lice in a five-page Bulletin (No. 2) issued by the Wyoming station in August.——In Bulletin No 3 of the New Mexico station Professor C. H. Tyler Townsend discusses a number of fruit insects.——In the report of the Maine station for 1890 Professor F. L. Harvey gives a popular account of a number of injurious insects which have attracted attention during the year.——Professor J. B. Smith's account of his year's work in the 1890 report the New Jersey station contains many results of great practical value.

MICROSCOPY.[1]

Methods of Preserving Human Embryos.—It frequently happens that human embryos which come into my possession are almost ruined by the physician's carelessness in preserving the material. For instance, I have obtained specimens simply placed in water, a solution of policylic acid, strong alcohol, or simply packed in cotton or even forced into a small bottle. Any of these methods almost totally spoil the specimen for careful study.

An abundance of material comes into the hands of the physician, and through his kindness it becomes possible to throw as much light on human embryology as on that of any of the other mammals. During the last few years several embryologists, especially Prof. His, have not only added a great deal to our knowledge of human embryology, but

[3] Outlines of Entomology. Prepared for the use of farmers and horticulturists. By Mary E. Murtfeldt. Report of the Missouri State Horticultural Society for 1890. Also issued separately, pp. 130, Figs. 48.

[1] Edited by C. O. Whitman, Clark University.

to vertebrate embryology in general, by the careful study of a few human embryos. Only a glance at the new edition of Quain's "Anatomy" will convince any one of this fact.

Of a dozen human embryos, less than six months old, which have come into my possession during the last few years, only one has been found well preserved and suited for careful study. For this reason I address this note especially to those who in the future will be kind enough to send me material.

In cases of early abortion the physician that attends pays no attention whatever to the embryo, or only preserves it carelessly in alcohol. Often it is impossible to find the embryo within the blood and particles which are extruded. If in all these cases the suspected material were, without previous examination, placed simply in seventy per cent. alcohol, most valuable specimens would often be obtained. When the ovum comes away unruptured, it nearly always ruins the specimen to examine it. It should be placed at once in a large quantity of Müller's fluid, or in alcohol. If these are not at hand the ovum should be kept temporarily in a large open-mouthed bottle until the hardening fluid can be obtained. The specimen, even if not opened, can be injured very easily by handling or by wrapping it with cotton or cloth. In all these cases it is not advisable to throw injured specimens away, for poor material is of value for dissection, and certainly is better than none at all.

Gynecologists, who are more especially interested in this subject, frequently have beautiful collections of specimens, and are by no means inclined to part with them. Yet the advancement of embryology has shown that it is necessary to destroy, or rather to lay into sections, the embryos before they can be studied properly. After a good specimen is once sectioned, the whole embryo or any part of it can be modeled quite easily on a large scale. This is necessary before the parts can be studied properly, and it requires a great deal of time and a considerable amount of costly apparatus. For this reason the embryologist feels justified in asking the gynecologist to part with his highly prized material.

Those physicians who have small laboratories, and are acquainted with the ordinary technique of hardening, should by all means harden specimens in Perenyi's chromonitric acid, in Kleinenberg's alcoholic picrosulphuric acid, in ten per cent. nitric acid, or in saturated solution of corrosive sublimate. Others who are not familiar with the above technique should use Müller's fluid or seventy per cent. alcohol. The latter is in general the best, and an amount of the alcohol equal

to at least five times the volume of the specimen should be used. When a specimen is to be transported by mail or express it should be transferred to a smaller bottle of alcohol of the same strength, and a very small *loose* cotton plug placed both above and below it.—F. Mall, *Clark University*.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

The National Academy of Sciences met in New York at Columbia College from November 10th to 12th, inclusive. The follow ing papers were read: Some Aspects of Australian Vegetation; G. L. Goodale. The Nomenclature of Vegetable Histology; G. L. Goodale. On Certain New Methods and Results in Optics; Charles S. Hastings. An Exhibition of the New Pendulum Apparatus of the U. S. Coast and Geodetic Survey, with Some Results of Its Use; T. C. Mendenhall. On the Use of a Free Pendulum as a Time Standard; T. C. Mendenhall. On Degenerate Types of Scapula, and Pelvic Arches in the Lacertilla; E. D. Cope. The Proteids or Albuminoids of the Oat-Kernel (second paper); Thomas B. Osborne. Astronomical Methods of Determining the Curvature of Space; C. S. Peirce. On Geographical Variation Among North American Birds, Considered in Relation to the Peculiar Intergradation of *Colaptes auratus* and *C. cafer*; J. A. Allen. On the Variation of Latitude; S. C. Chandler. The Tertiary Rhynchitidæ of the United States; Samuel H. Scudder. On a Color System; O. N. Rood. Preliminary Notice of the Reduction of Rutherfurd's Photographs; J. K. Rees. On the Application of Spectrum Analysis to the Analysis of the Rare Earths, and a New Method for the Preparation of Pure Yttrium; H. A. Rowland. A Nomenclator of the Families of Fishes; Theodore Gill. Measurement of Jupiter's Satellites by Interference; A. A. Michelson. The Follicle Cells of Salpa; W. K. Brooks. The academy was entertained on the evening of the 10th by President Low, of Columbia College; and on that of the 11th by Mrs. Henry Draper. A part of the latter entertainment consisted of an illustrated lecture by Prof. E. C. Pickering on the work of the Draper memorial fund in astronomical research in South America.

Biological Society of Washington.—*October 17th.*—The following communications were made: Food Plants of the Indians of the Death Valley Region; Frederick V. Coville. Notes on Paleopathol-

ogy, R. W. Shufeldt. The Fate of the Fur Seal in American Waters (with lantern illustrations); William Palmer.

October 31st.—The Classification of the Tetrodontoidea; Theodore Gill. Some Fishes New to New England Waters; T. H. Bean. Cuckoo Stomachs and Their Contents; Walter B. Barrows. The Temperature of Trees; N. H. Egleston. Notes on Parasites: Development of *Echinorhynchus gigas;* C. W. Stiles.

November 14th.—Winter Aspects of the Mojave Deseet Region; T. S. Palmer. A Case of Echinococcus in Swine; V. A. Moore. Notes on Parasites: *Coccidium bigeminum* Stiles; C. W. Stiles. Haeckel's Radiolaria of the Challenger Expedition; L. F. Ward. Three Days in the Tropics; L. F. Ward.—FREDERICK A. LUCAS, *Secretary.*

Boston Society of Natural History.—*November 4th.*—The following papers were read: The Natural History Museums of Australasia; G. L. Goodale. Recent Fossils of the Harbor and Back Bay, Boston; Warren Upham.—SAMUEL HENSHAW, *Secretary.*

SCIENTIFIC NEWS.

The Princeton University Geological Expedition under Prof. W. B. Scott has returned with much valuable booty. They explored the valley of Deep River, Montana, where the Ticholeptus beds are seen, and obtained a good series of the vertebrate species described from those beds by Cope, together with some additional ones. Prof. Scott finds three horizons of fossils in the valley, one of which at least is Loup Fork, while the lowest one is nearly allied to the John Day bed.

The expedition on behalf of the American Museum of Natural History, of New York, under direction of Dr. J. L. Wortman, explored the Wind River and Big Horn Eocene regions in Wyoming, the past summer. Dr. Wortman was very successful, and we shall have considerable new information respecting the interesting faunæ which these beds contain in the forthcoming report on them by Prof. Osborn and Dr. Wortman.

Prof. H. F. Osborn has accepted the position of Professor of Biology in Columbia College, New York.

Prof. Frederick Starr has accepted the chair of ethnology and archeology in the Rockefeller University of Chicago.

Prof. C. H. Gilbert is Professor of Vertebrate Biology in the Leland Stanford University of California.

The December number of the *North American Review* will contain a symposium on The Quorum in European Legislatures, apropos of the probable renewal of the Speakership controversy on the assembling of Congress, December 7. This contribution will include statements as to European usages, in reference to the point at issue, by M. Louis Ruchonnet, President of the Swiss Confederation; Herr Von Levetzow, President of the German Reichstag; M. Henri Brisson, ex-President of the Chamber of Deputies; M. Jules Meline, ex-Minister of Agriculture; M. Sofus Hogsbro, President of the Danish Folkething; Sig. Chiavassa of the Italian Senate, and others. The same number will also contain The Three Philanthropists, by Colonel R. G. Ingersoll; The Benefits of War, by Admiral Luce; A Great Statistical Investigation, by Carroll D. Wright, and Railway Rates, by General Horace Porter. Further contributions will appear in the same number from Signor Crispi, ex-Prime Minister of Italy; the Dean of St. Paul's Cathedral, London; T. V. Powderly, and Prof. James Bryce, author of The American Commonwealth.

Whaley